MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 115 No. 2 1955

ANNUAL REPORT OF THE COUNCIL

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NOTICE TO AUTHORS

1. *Communications.*—Papers must be communicated to the Society by a Fellow. They should be accompanied by a summary at the *beginning* of the paper conveying briefly the content of the paper, and drawing attention to important new information and to the main conclusions. The summary should be intelligible in itself, without reference to the paper, to a reader with some knowledge of the subject; it should not normally exceed 200 words in length. **Authors are requested to submit MSS. in duplicate. These should be typed using double spacing and leaving a margin of not less than one inch on the left-hand side. Corrections to the MSS. should be made in the text and not in the margin.** Unless a paper reaches the Secretaries more than seven days before a Council meeting it will not normally be considered at that meeting. By Council decision, MSS. of accepted papers are retained by the Society for one year after publication; unless their return is then requested by the author, they are destroyed.

2. *Presentation.*—Authors are allowed considerable latitude, but they are requested to follow the general style and arrangement of *Monthly Notices*. References to literature should be given in the standard form, including a date, for printing either as footnotes or in a numbered list at the end of the paper. Each reference should give the **name and initials** of the author cited, irrespective of the occurrence of the name in the text (some latitude being permissible, however, in the case of an author referring to his own work). The following examples indicate the style of reference appropriate for a paper and a book, respectively :—

A. Corlin, *Zs. f. Astrophys.*, **15**, 239, 1938.
H. Jeffreys, *Theory of Probability*, 2nd edn., section 5.45, p. 258, Oxford, 1948.

3. *Notation.*—For technical astronomical terms, authors should conform closely to the recommendations of Commission 3 of the International Astronomical Union (*Trans. I.A.U.*, Vol. VI, p. 345, 1938). Council has decided to adopt the I.A.U. 3-letter abbreviations for constellations where contraction is desirable (Vol. IV, p. 221, 1932). In general matters, authors should follow the recommendations in *Symbols, Signs and Abbreviations* (London : Royal Society, 1951) except where these conflict with I.A.U. practice.

4. *Diagrams.*—**These should be designed to appear upright on the page, drawn about twice the size required in print and prepared for direct photographic reproduction except for the lettering, which should be inserted in pencil. Legends should be given in the manuscript indicating where in the text the figure should appear.** Blocks are retained by the Society for 10 years; unless the author requires them before the end of this period they are then destroyed.

5. *Tables.*—**These should be arranged so that they can be printed upright on the page.**

6. *Proofs.*—Costs of alterations exceeding 5 per cent of composition must be borne by the author. Fellows are warned that such costs have risen sharply in recent years, and it is in their own and the Society's interests to seek the maximum conciseness and simplification of symbols and equations consistent with clarity.

7. *Revised Manuscripts.*—When papers are submitted in revised form it is especially requested that they be accompanied by the original MS.

Reading of Papers at Meetings

8. When submitting papers authors are requested to indicate whether they will be willing and able to read the paper at the next or some subsequent meeting, and approximately how long they would like to be allotted for speaking.

9. Postcards giving the programme of each meeting are issued some days before the meeting concerned. Fellows wishing to receive such cards whether for Ordinary Meetings or for the Geophysical Discussions or both should notify the Assistant Secretary.

Dr J. Jackson, C.B.E., F.R.S.
President 1953–1955

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 115 No. 2

ANNIVERSARY MEETING OF 1955 FEBRUARY 11

Dr J. Jackson, President, in the Chair

The election by the Council of the following Fellows was duly confirmed :—

Mohd Akhtar, Holcombe, Station Road, Balsall Common, Warwickshire (proposed by A. Hunter) ;

Cecil Arthur Gordon Bearpark, Orion, Broomfield Ride, Oxshott, Surrey (proposed by R. C. Wood) ;

*Herman Lawrence Helfer, 1592 Jesup Avenue, New York 52, New York State, U.S.A. (proposed by S. Chandrasekhar) ;

Egbertus Korving, 54 Frederick Street, London, W.C.1 (proposed by H. Wildey) ;

James Dwyer McGee, M.Sc., Ph.D., A.M.I.E.E., Imperial College of Science and Technology, South Kensington, London, S.W.7 (proposed by P. M. S. Blackett) ;

*Paul Harry Roberts, B.A., Gonville and Caius College, Cambridge (proposed by S. Chandrasekhar) ;

Denys Henry Ruddy, M.A., 5 Grosvenor Crescent, Grimsby, Lincolnshire (proposed by H. E. Ruddy) ;

*Roger John Tayler, B.A., Buckland House, Buckland, near Faringdon, Berkshire (proposed by F. Hoyle) ;

James Stillman Wadsworth, Lieut.-Col., Church Cottage, Southease, Lewes, Sussex (proposed by G. H. Laver) ; and

Richard Wort, T.D., 73 Murray Road, Wimbledon, London, S.W.19 (proposed by W. M. Smart).

*Transferred from Junior Membership.

One hundred and twenty presents were announced as having been received since the last meeting.

The President announced that Professor Dirk Brouwer would deliver the George Darwin Lecture at the Ordinary Meeting of 1955 April 6, taking "The Motions of the Outer Planets" as his subject.

The President gave an address on the award of the Gold Medal to Professor Dirk Brouwer (see p. 199).

The President gave an address on the award of the Eddington Medal to Professor H. C. van de Hulst (see p. 202).

The President then delivered his address on "The need for observations in the older branches of astronomy, especially double stars" (see p. 204).

ANNUAL GENERAL MEETING OF 1955 FEBRUARY 11

Dr J. Jackson, President, in the Chair

The Minutes of the preceding Annual General Meeting were read, confirmed and signed.

The Secretaries, on behalf of the Council, moved the adoption of the following resolution:—

> "That this Annual General Meeting authorizes the sale to the Director of the Cambridge Observatories of Instrument No. 157, a Schmidt Camera of aperture 6 inches and focal ratio $f/1{\cdot}5$, the property of the Society."

After some discussion, Mr P. N. Ryves proposed and Mr F. M. Holborn seconded that the camera be advertised as available for loan before considering further the question of sale. This amendment was defeated and the original motion carried.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year.

The Treasurer gave a brief explanation of the accounts and a survey of the Society's financial position.

The Report of the Honorary Auditors was read (see p. 115).

A vote of thanks to the Honorary Auditors of the Treasurer's accounts for 1954 was proposed and carried unanimously.

It was proposed and carried that the Report of the Council be received and adopted, and that it be printed and circulated in the usual manner, together with the Report of the Honorary Auditors and the President's Address.

The Scrutineers reported to the President the result of the ballot, and the names of the Officers and Council elected for the ensuing year were read to the Meeting. (The list of names is given on p. 216.)

The retiring President called upon his successor, Sir Harold Jeffreys, to take the Chair. He did so amid applause, and expressed his thanks to the Fellows for the honour they had done him.

The thanks of the Society were given to the retiring President (Dr J. Jackson), Vice-Presidents (Professor W. H. McCrea and Mr D. H. Sadler), Foreign Secretary (Professor F. J. M. Stratton), and other members of Council.

The thanks of the Meeting were given to the Scrutineers of the ballot.

The Meeting then adjourned.

REPORT OF THE COUNCIL TO THE HUNDRED AND THIRTY-FIFTH ANNUAL GENERAL MEETING OF THE SOCIETY

This Report refers to the calendar year 1954

1. *Membership.*—The table on p. 115 shows that the slow but steady post-war increase of membership continues. Whilst it is true that elections do not take place at the rate shown by some other comparable learned Societies, few new Fellows resign within a year or two of election. It is hoped that the continuation of the agreement with the Editors of *The Observatory* magazine, together with the increased rate of publication of *Occasional Notes*, have tended to keep the interest of those less technically minded Fellows on whose support the Society to a large extent depends.

The Society lost by death the following Associates :

Thaddäus Banachiewicz
Ernest Esclangon

and the following Fellows :

*Selig Brodetsky	Henry Russell Maynard
Arthur Kington Chapman	Henri Mineur
Charles Clifford Conroy (1953)	*Edward Dominic O'Connor
Frederick Richard Cripps	Geoffrey Harold Ramsden (1953)
Inigo Owen Jones	*Robert Fermor Rendell
*Michael Stephanovitch Kovalenko	Ralph Leslie Robinson
Sidney Ivor Luck	Robert Meldrum Stewart

*Life Fellow.

Obituary notices of many of these appear on pp. 124–130 together with some others held over from the last report.

2. *Finance.*—Last year the Council decided to print only quinquennially the full details of Gifts and Trusts, but to continue annually to commemorate the generosity of donors in the list following the Treasurer's accounts. This year the list records a new and important gift, namely provision under covenant by Mr Jack Miller for the purchase of the National Geographic Society–Palomar Observatory Sky Atlas and a cabinet to accommodate it. The estimated cost of the Atlas is $2000, payable over a period of some three years as the sections of the Atlas become available. Mr Miller has covenanted to make the Society an annual gross payment of £100 for seven years to cover the full cost of the Atlas.

This year's accounts show a deficit of £552 as compared with a surplus of £462 last year. This year the Society received, through the Royal Society, £800 from the Parliamentary Grant-in-Aid for Scientific Publications; last year the corresponding sum was £1000. Were it not for these allocations the accounts would have shown a deficit of £538 for 1953 and £1352 for 1954.

The worse result this year is largely explained by an increase in the printing bill because of the inclusion of one more part of *Monthly Notices* and additional *Occasional Notes*, but the position nevertheless gives no grounds for complacency.

To aid progress towards balancing the accounts is in the power of every non-compounding Fellow, part of whose income is subject to the full standard rate of United Kingdom income tax, and that at no cost to himself. By paying his annual contribution under a seven-year covenant, he almost doubles its cash value to the Society. To remove misgivings, it may be said that such a covenant would lapse on death and so would not constitute a continuing liability.

A measure which the Council has under consideration is an overhaul of the Society's investment policy, in particular the desirability of turning to investment in equities as a partial protection against the present inflationary trend.

3. *Meetings.*—Eight Ordinary Meetings and four Geophysical Discussions were held at Burlington House during 1954. No George Darwin Lecture was delivered, since Dr W. Baade, who had been asked to give it, found it impossible to visit the United Kingdom during the year.

No provincial meeting was arranged for the summer months; many Fellows however participated in the joint expedition with the British Astronomical Association to view the total solar eclipse of 1954 June 30. The party, numbering some 130, were fortunate with the weather. A good view of a typical "minimum" corona was obtained from Strömstad, though the sky was not perfect; and the ten-day trip was generally regarded as well worth while.

Astronomers from overseas who were welcomed at the Society's meetings included Professor V. A. Ambartsumian (U.S.S.R.), Dr K. E. Bullen (Australia), Dr F. Gondolatsch (Germany), Dr J. Houtgast (Holland), Miss Lippincott (U.S.A.) and Monsieur H. Michel (Belgium).

4. *Publications.*—During the year 1954 the Society published and distributed the following:

Monthly Notices, Vol. **113**, Nos. 4, 5, 6; Vol. **114**, Nos. 1, 2, 3.
Geophysical Supplement, Vol. **6**, No. 9; Vol. **7**, No. 1.
Memoirs, Vol. **67**, Part 1.
Occasional Notes, Nos. 15, 16, 17.
List of Fellows.

The new *Memoir* is the first published since the war. As long-term observational programmes, started when hostilities ceased, reach completion, further papers suitable for this series will doubtless be communicated in future. Fellows are reminded that distribution is confined to those who ask the Assistant Secretary to put their names on the list for *Memoirs*.

Mr D. H. Sadler resigned as Editor of *Occasional Notes* after the production of No. 17. His term of office has been marked by characteristic energy, and the three issues published during this period show a breadth of appeal which is reflected in their sales to the general public. Mr Sadler is succeeded by Dr E. M. Burbidge. By a Council decision last March, Junior Members will in future receive copies of *Occasional Notes* free of charge.

The new *List of Fellows* is the first publication of the Society to be produced by a method different from conventional type-setting. It was set on an electric typewriter and reproduced by photolithography. In present circumstances

this method is both quicker and very much cheaper than conventional printing, and though it must be admitted that the resulting booklet has not the impeccable appearance of letterpress, it is not unpleasing and the process is thought to be quite suitable for ephemeral publications.

The *General Index* referred to in last year's Report has been delayed by pressure of more urgent work, but it will appear in 1955.

5. *Awards.*—The Council awarded the Gold Medal for 1954 to Dr Walter Baade for his observational work on galactic and extragalactic objects. The Presidential Address by Dr Jackson on the award (*M.N.*, **114**, 370, 1954) was read in the President's absence by the Vice-President, Professor H. Dingle, at the Anniversary Meeting.

Professor J. Dufay (Lyon), Professor M. Waldmeier (Zürich) and Professor H. Zanstra (Amsterdam) were elected Associates during the year.

6. *Library.*—The re-organization of the Library is now substantially complete. The Assistant Librarian, Mr R. Kenedy, resigned to take up another post in March, two months before his formal engagement was due to end. In order to meet the situation arising from this circumstance, the Librarian, Miss E. Wadsworth, agreed to attend more frequently than her original terms of engagement called for, and Library service to Fellows was confined for some months to Fridays only. The work progressed well during the summer, and by the autumn it was clear that an Assistant could be appointed as planned, to overlap with Miss Wadsworth for some weeks before she retired at the end of the calendar year. Some 120 applications were received in answer to an advertisement and as a result of an interview at which nine candidates were considered, the post was offered to and accepted by Mrs M. H. Markiewicz, F.L.A., who will assume the full duties of Librarian at the beginning of 1955.

With the retirement of Miss Wadsworth the Society loses a devoted servant who first joined the office staff as Clerk in 1923 and has served subsequently as Assistant Secretary (taking over this post in 1942 at a particularly difficult stage of the Society's history) and as Librarian. In each capacity she has shown initiative and energy, as many Fellows and (in particular) many ex-Officers can testify. The Council has resolved to make her a small gift from the Society as a memento of her long service, and the President will present this to her at the Anniversary Meeting.

During the autumn the Society lent a number of its more precious old books to the Science Museum. Together with other ancient astronomical books belonging to the Museum Library, they formed a special exhibition that attracted much attention. The books were returned safely at the end of December.

By the end of the year the remainder of the Kuffner Library was disposed of, some sections going to the Observatory Libraries at Cambridge, at Manchester and at Mill Hill, and the remainder to booksellers. British astronomy is greatly indebted to Mr Stefan Kuffner whose generosity as donor of this collection has made possible many valuable additions to the Society's Library as well as to other astronomical libraries throughout the country. From the proceeds of the sale of such parts of the collection as were not required in the Society's Library it will be possible in the future to make many purchases that would otherwise have depleted the General Fund. The Society is also much indebted

to the Astronomer Royal, who kindly arranged the transport of the books from Austria to the United Kingdom and their storage at Greenwich until they were disposed of.

7. *The Society's premises.*—A new projection screen has been installed in the Meeting Room, the cost being shared equally between the Society and the British Astronomical Association. A new 500-watt projector will enable two-inch slides and film strips to be shown.

Repairs and redecorations have been effected during the year in the B.A.A. Library, in the Spencer Room and in the Assistant Secretary's office. The Herschel cupboard on the first floor has been fitted with shelves to take office records, which are now for the first time stored accessibly in filing boxes.

The portrait of Francis Baily which hangs in the Council room has been repaired and cleaned.

8. *Memorial to William Herschel.*—Towards the end of 1953 Mr J. E. Bullard drew the attention of the Council to the fact that no adequate mention of William Herschel appeared anywhere in Westminster Abbey. Negotiations with the Abbey authorities during the early months of 1954 culminated in August in the laying of a memorial stone with a simple inscription in the north aisle of the nave. At an informal memorial service conducted in the Abbey by the Dean on 1954 November 8 the President of the Society gave a short appraisal of Herschel's work in relation to modern astronomy (*The Observatory*, **74**, 243, 1954). The Society is indebted to Mr Bullard not only for drawing attention to the lack of any mention of Herschel in the Abbey but also for meeting the full cost of the memorial tablet.

9. *Isaac Newton Observatory.*—Further tests of the 98-inch spherical main mirror were made in August, during the works holiday period, at Sir Howard Grubb, Parsons & Co.'s works. The mirror was supported in a horizontal position by an inflated bag so that it was not subjected to any distortion. The mirror was found to be substantially free from astigmatism and its figure, though not yet perfect, is reasonably good. The tests showed some differences from the earlier tests, which it was thought might indicate that some slight change in its figure had occurred. Though it is unlikely that this is the explanation, it was decided that further similiar tests should be made at a later date to check whether any change in figure was taking place.

Of the two off-axis forms of mounting mentioned in last year's Report, the design in which the telescope is mounted between stiff forks from the top of a truncated conical polar axis is preferred by the Board of Management. This design, though preferable for mounting a Cassegrain spectrograph, is not so favourable for the design of the coudé spectrograph. The Board of Management has appointed a small Executive Committee to discuss the details of the optical and mechanical design with Sir Howard Grubb, Parsons & Co., with whom a design study contract has been placed.

The construction and testing of a mechanism designed to investigate the principle of stiffening the supporting system of the Gregorian secondary mirror by a hydraulic servo system is being undertaken by the Engineering Laboratory of Cambridge University.

10. *National Geographic Society–Palomar Observatory Sky Atlas.*—The Society has placed an order for this atlas of the sky, to be prepared from photographs taken with the 48-in. Schmidt camera on Palomar Mountain. The cost of the Atlas and of a suitable cabinet for housing the 1758 prints (14 in. × 17 in.) it comprises will be met in full from a most generous gift by Mr Jack Miller, who has agreed to allow his name to be permanently associated with this gift.

11. *Representation of the Society.*—The Society was represented at the bicentenary celebrations of the Royal Society of Arts in March by the President, who presented an Address of Congratulation from the Society. At the Poincaré centenary celebrations at Paris in May Professor L. M. Milne-Thomson conveyed the Society's felicitations.

Representatives of the Society were appointed during the year as follows :

on the National Committee for Astronomy,
Professor C. W. Allen,
Dr R. A. Lyttleton,
Professor R. O. Redman;
on the National Committee for Geodesy and Geophysics,
Professor V. C. A. Ferraro;
on the Board of Management of the Isaac Newton Observatory,
Mr G. T. Clarke-Smith;
on the Board of Visitors of the Royal Greenwich Observatory,
Professor A. C. B. Lovell;
on the Cambridge University Committee for Geodesy and Geophysics,
Professor V. C. A. Ferraro.

REPORT OF THE HONORARY AUDITORS FOR THE YEAR 1954

We have examined the professionally audited accounts of the Society and have checked the official list of Fellows against the subscriptions received. We are pleased to report that the membership continues to increase steadily.

On examining the premises of the Society we noted with satisfaction that progress had been made in redecorating certain rooms on the second floor. We strongly recommend that the programme of redecoration be continued, attention being given in the first place to ceilings in the Upper Library and the Lumber Room. In order to prevent possible deterioration of the Society's instruments cleaning and redecoration of the instrument store is also desirable.

We recommend the renewal of certain sections of the electric lighting circuits.

A new filing system for office records has been inaugurated, and we are sure that this will ease the burden of work on the Office Staff.

We acknowledge with gratitude the help and cooperation given to us by the Assistant Secretary in providing the information we required.

R. H. GARSTANG
J. A. CLEGG

PROGRESS AND PRESENT STATE OF THE SOCIETY

	Patron	Institutional Members	Fellows		Junior Members	Associates	Total
			Compounders	Annual Contributors			
1954 January 1	1	6	201	829	31	50	1118
Since elected		...	...	64	15	3	82
Junior Members elected to Fellowship ...		...	...	7	— 7	...	0
Deceased 1954		...	— 5	— 8	...	— 2	— 15
Deceased before 1954, notified in 1954 ...		...	...	— 2	...	...	— 2
Since compounded		...	3	— 3	...	...	0
Resigned 1954		...	...	— 10	— 3	...	— 13
Election void		...	...	...	— 1	...	— 1
Names removed		...	...	— 7	...	...	— 7
Name removed, presumed deceased		...	— 1	...	...	...	— 1
1955 January 1	1	6	198	870	35	51	1161

(N.B.—Thirteen Associates are also Fellows, and are therefore counted twice in the above table.)

Dr. *General Fund Revenue Account*

	£	s.	d.	£	s.	d.	*1953* £
To Salaries and Wages, including Pension Premiums and National Insurance				2,109	19	0	*2,087*
,, Insurance and Telephone				60	4	0	*52*
,, Printing etc.							
Monthly Notices, Vol. 113, No. 6	530	1	1				
,, ,, Vol. 114	2,834	18	5				
Geophysical Supplement, Vol. 6, No. 9, Vol. 7, No. 1	394	3	10				
Occasional Notes, Vol. 3, Nos. 16 and 17	398	15	2				
Memoirs, Vol. 67, Part I	210	0	0				
List of Fellows	89	16	3				
Paper Supply	374	14	1				
Miscellaneous printing and carriage	376	9	6				
	5,208	18	4				*4,167*
Less Amount received for 1954 from the Parliamentary Grant-in-Aid for Scientific Publications through the Royal Society	800	0	0				*1,000*
				4,408	18	4	*3,167*
,, Posting and Packing				241	12	11	*234*
General Expenses :—							
Stationery and Office Expenses	99	2	5				
Lighting and Heating	229	12	6				
Travelling Expenses	9	8	11				
Subscriptions to National Central Library and A.S.L.I.B.	4	4	0				
Accountants' Fees	63	0	0				
Gold Medal	14	13	11				
Furniture and Fittings, including repairs	132	19	1				
I.A.U. Telegram Service	11	15	4				
House Expenses	67	14	6				
Meeting Expenses	48	11	6				
Library Expenses	2	12	6				
Sundries	61	11	1				
				745	5	9	*868*
,, Block Subscription to *The Observatory*				190	0	0	*190*
,, Purchase of Books				5	17	11	*13*
,, Reserve for Repairs				300	0	0	*300*
,, Binding of Periodicals, etc.				197	12	8	*86*
,, Reproduction of Photographic Slides and Prints				248	11	7	*194*
,, Films, Hire and Expenses					...		*21*
,, Reprint Expenses				6	0	0	...
,, Sweden Meeting Expenses (Eclipse)				3	6	10	*23*
				£8,518	9	0	*1,226*

One Year to 1954 December 31 *Cr.*

	£ s. d.	£ s. d.	£ s. d.	*1953* £
By *Amounts received from Fellows* :—				
3 Partial Annual Contributions for 1952 ...	6 6 0			
7 Annual Contributions for 1952	22 1 0			
2 Partial Annual Contributions for 1953 ...	2 14 0			
32 Annual Contributions for 1953 ...	100 16 0			
15 Admission Fees for 1953	31 10 0			
15 First Contributions for 1953	15 15 0			
1 Junior Member's Annual Contribution for 1953	1 1 0			
772 Annual Contributions, 1954	2,431 16 0			
2 Partial Payments, 1954	3 14 0			
5 Institutional Membership Fees, 1954 ...	15 15 0			
37 Junior Members' Annual Contributions, 1954	38 17 0			
43 Admission Fees, 1954	90 6 0			
53 First Contributions, 1954	139 13 0			
		2,900 4 0		*2,723*
Income Tax recovered on those under Covenant		442 18 0		*450*
,, *Composition Fees* :—				
Reduced Fees	114 9 0			
Add Special donations from Compounders (including £22 11*s.* 8*d.* tax recovered on Covenants)	52 8 8			
	166 17 8			
Less Transferred to Reserve Account ...	166 17 8			
	... ...			
Add Amount brought to Credit for the year	164 10 9			*165*
		164 10 9		
			3,507 12 9	*3,338*
,, Interest and Dividends received (gross)		1,105 15 1		
,, Interest received on Bank Deposit Accounts ...		122 11 11		
,, Profit on Redemption of Investment		10 0 0		
			1,238 7 0	*1,243*
,, Sales of Publications, Photographs and Miscellaneous Receipts for the year :				
Monthly Notices, Vol. 112 and earlier ...		174 2 3		*269*
,, ,, Vol. 113		23 13 8		*26*
,, ,, Vol. 114		1,262 17 10		*1,190*
Geophysical Supplement		353 9 7		*315*
Memoirs, Occasional Notes and Miscellaneous		375 19 11		*142*
Reprints		496 4 8		*654*
Palomar Slides and Prints		185 12 10		*171*
R.A.S. Slides and Prints		110 19 3		*88*
Hire of Films		27 10 2		*50*
British Astronomical Association		168 0 0		*168*
London Mathematical Society		40 0 0		*30*
Sundries		1 8 4		*3*
			3,219 18 6	*3,106*
			7,965 18 3	*7,687*
,, Deficit, one year to date (Surplus in previous year)			552 10 9	*—462*
			£8,518 9 0	*7,226*

Balance Sheet

	£ s. d.	£ s. d.	£ s. d.
General Fund :—			
As at 1953 December 31		30,348 1 1	
Less Excess of Expenditure over Income, 1954 ...		552 10 9	
			29,795 10 4
Trust Funds :—			
Capital as at 1953 December 31		7,459 10 2	
Income Balances as at 1954 December 31 ...		1,858 5 7	
Income Tax on Trust Funds, 1954 April–December not yet refunded		19 10 8	
			9,337 6 5
Arthur Stanley Eddington Commemoration Fund :—			
As at 1953 December 31		409 2 6	
Income Balance at 1954 December 31		55 6 8	
			464 9 2
Mr. Jack Miller's Gift—Palomar Sky Atlas Fund :—			
Received in 1954		55 0 0	
Income Tax not yet refunded		45 0 0	
			100 0 0
Repairs and Maintenance Reserve :—			
As at 1953 December 31	527 7 11		
Add Set aside 1954	300 0 0		
		827 7 11	
Less Expenditure 1954		228 0 7	
			599 7 4
Sale of Discarded Books Fund :—			
As at 1953 December 31		615 6 6	
Add Sales, 1954		225 10 0	
Interest, 1954		14 12 0	
			855 8 6
Composition Fees Reserve Fund :—			
As at 1953 December 31	2,575 7 10		
Received in 1954	114 9 0		
Special Donations	52 8 8		
		2,742 5 6	
Less 6 per cent transferred to Revenue Account ...		164 10 9	
			2,577 14 9
Staff Pension Fund :—			
As at 1953 December 31		607 2 9	
Add Interest for 1954		15 3 0	
			622 5 9
Benevolent Fund :—			
Balance at 1954 December 31			20 0 2
Amounts received in Advance :—			
Contributions :			
1955 paid in 1952	3 3 0		
1955 paid in 1953	9 9 0		
1956 paid in 1953	6 6 0		
1957 paid in 1953	3 3 0		
1958 paid in 1953	3 3 0		
1955 paid in 1954	129 2 0		
1956 paid in 1954	6 6 0		
		160 12 0	
Publications, 1955		126 0 9	
			286 12 9
Sundry Creditors for Accounts due but not presented (including provision for printing publications for 1954 and binding periodicals, not yet completed) ...			3,867 0 5
			£48,525 15 7

To the Fellows of THE ROYAL ASTRONOMICAL SOCIETY

We have examined the above Balance Sheet with the Books and Vouchers relating thereto explanations given to us.

We have verified the Securities representing the Investments and have found them to be

SUFFOLK HOUSE,
5 LAURENCE POUNTNEY HILL, LONDON, E.C.4.
1954 February 4

1954 *December* 31

	£	s.	d.	£	s.	d.
Investments :—						
General Fund, valued as at 1922 December 29 or subsequent cost ...	30,984	17	6			
Trust Funds, valued at cost	7,548	2	2			
(Market value 1954 December 31, £39,725 0s. 0d.)				38,532	19	8
Debtors :—						
General	500	12	6			
Income Tax Recoverable :						
General Fund	24	6	8			
Trust Funds	19	10	8			
Palomar Sky Atlas Fund	45	0	0			
				589	9	10
Deposits at Savings Bank :—						
General Fund	£6,327	7	9			
Trust Funds	848	18	11			
	7,176	6	8			
Balance on Current Account at Bank and Cash in Hand :—						
General Fund	1,306	4	9			
Trust Funds	920	14	8			
	2,226	19	5			
				9,403	6	1

Note.—Contributions unpaid as at 1954 December 31, and amounting to £213 13s. 0d., have not been included in this Balance Sheet.

£48,525 15 7

and certify it to be correctly drawn up therefrom and in accordance with the information and in order.

SHARP, PARSONS & CO.,
Chartered Accountants.

INVESTMENTS

As at 1954 December 31

General Fund

£2000 Swansea Corporation 3½ per cent Stock.
£7386 12*s.* 9*d.* British Transport 3 per cent Guaranteed Stock, 1978/88.
£496 Consolidated 4 per cent Stock, 1957.
£1035 Agricultural Mortgage Corporation, Ltd., 4½ per cent Debenture Stock, 1961–91.
£700 Birmingham Corporation 3 per cent Stock, 1947.
£2280 5*s.* 3*d.* War Loan 3½ per cent Inscribed Stock.
£1156 1*s.* 5*d.* Metropolitan Water 3 per cent "B" Stock.
£500 Savings Bonds 2½ per cent, 1964/67.
£2118 3*s.* 5*d.* Savings Bonds 3 per cent, 1960/1970 (Holding "A").
£695 16*s.* 0*d.* Conversion Loan 3½ per cent, 1961.
£2239 13*s.* 8*d.* Treasury 2½ per cent Stock, 1975.
£3050 13*s.* 0*d.* British Electricity 3 per cent Guaranteed Stock, 1968–73.
£3718 British Gas 3 per cent Guaranteed Stock, 1990–95.
£500 Commonwealth of Australia 3 per cent Loan, 1972–74.
£78 1*s.* 3*d.* War Loan 3½ per cent Registered Stock.
£2400 Defence Bonds 3 per cent (5th Issue).
£3468 12*s.* 10*d.* Consolidated Stock 2½ per cent.
£880 Defence Bonds 3 per cent (5th Issue).
£2009 5*s.* 3*d.* Hull Corporation 3¾ per cent Redeemable Stock, 1973–75

Trust Funds

£1004 Consolidated 4 per cent Stock, 1947.
£965 Agricultural Mortgage Corporation, Ltd., 4½ per cent Debenture Stock, 1961–91.
£491 10*s.* 0*d.* War Loan 3½ per cent Inscribed Stock.
£1160 16*s.* 3*d.* War Loan 3½ per cent Inscribed Stock.
£542 18*s.* 2*d.* Savings Bonds 3 per cent, 1960/1970 (Holding "B").
£1122 19*s.* 6*d.* Savings Bonds 3 per cent, 1960/1970 (Holding "C").
£1471 4*s.* 0*d.* Savings Bonds 3 per cent, 1955/1965.
£375 Savings Bonds 3 per cent 1955/1965.
£100 Savings Bonds 3 per cent 1960/1970 (Holding "D").
£250 War Loan 3½ per cent Stock.
£100 Defence Bonds 3 per cent (5th Issue)

GIFTS AND BEQUESTS TO THE SOCIETY

Full details of the circumstances and amounts of the gifts and bequests listed below are published quinquennially, together with revenue statements concerning the Special Funds and Trust Funds. The latest statement appeared in *M.N.*, **113**, 287, 1953.

GIFT RECEIVED DURING 1954

Palomar Sky Atlas Fund (1954): During the year the Society received a most generous gift in that Mr Jack Miller has made provision under covenant for buying the National Geographic Society–Palomar Observatory Sky Atlas and providing a cabinet for housing it.

GIFTS TO THE GENERAL FUNDS AND PROPERTY OF THE SOCIETY

The John Lee Gift (1836 and 1844)
The Lawson Bequest (1856)
The Carrington Bequest (1876)
The Lambert Bequest (1877)
The McClean Bequest (1905)
The Farrar Bequest (1906)
The Parsons Gift (1922)
The Grove-Hills Bequest (1922)
The Grove-Hills Fund (1922)
The Lindemann Bequest (1931)
The Archdeacon Potter Bequest (1933 and 1951)
The Goodridge Bequest (1936)
The Herbert Spencer Bequest (1936)
The Lindley Bequest (1937)
The Stanley Williams Bequest (1939)
The E. W. Brown Bequest (1939)
The Plummer Bequest (1946)
The Carder-Davies Bequest (1948)
The M. A. Nadarov Bequest (1950)
The W. H. Owston Bequest (1951)
The Rev. Harold Pain Bequest (1953)

SPECIAL FUNDS

The Archdeacon Potter Fund (1933 and 1951)
The Victor Nadarov Fund (1950)
The Arthur Stanley Eddington Commemoration Fund (1948)
Benevolent Fund (1950)

TRUST FUNDS

The Lee and Janson Fund (1834 and 1879)
The Turnor Fund and the Horrocks Memorial Fund (1853 and 1876)
The Hannah Jackson (*née* Gwilt) Fund (1861)
The Harry Watson Memorial Fund (1923)
The George Darwin Lectureship Fund (1926)
The A. G. Stillhamer Trust (1937)
The E. W. Brown Trust (1939)
The Plummer Bequest (1946)

LIST OF PUBLIC INSTITUTIONS AND OF PERSONS WHO HAVE PRESENTED GIFTS (OTHER THAN BY EXCHANGE) TO THE LIBRARY DURING THE YEAR 1954

Academy of Sciences, U.S.S.R.
Accademia dei Lincei
American Association for the Advancement of Science
Association Française d'Observateurs d'Étoiles Variables
Association of Special Libraries and Information Bureaux
Astronomical Society of Edinburgh
Astronomical Society of South Africa
Astronomical Society of Tasmania
Astronomische Gesellschaft
British Association, Seismology Committee
British Astronomical Association, N.S.W. Branch
British Society for the History of Science
Cambridge University Press
Carnegie Institution of Washington
Central Radio Bureau
Commissione Geodesica Italiana
Commonwealth Scientific and Industrial Research Organization
F. Dümmlers Verlag
Geophysical Institute of the Faculty of Science, University of Zagreb
Goethe Link Observatory
Griffith Observatory, Los Angeles
C. Hamburgers Bogtrykkeri
Directors of the Hayden Planetarium
Hydrographer of the Navy
Imperial Chemical Industries
International Astronomical Union
International Union of Geodesy and Geophysics
Kommission Observatorium Wendelstein
Konkoly Observatory
Longmans, Green and Co.
Maria Mitchell Association
National Oceanographic Council
National Research Council of Canada
The Editors of *The Observatory*
Ole Rømer Observatoriet, Stockholm
Oporto, Faculdade de Sciências
C. A. Parsons and Co., Ltd.
Perkin-Elmer Corporation
Publishers of *Revue des Questions Scientifiques*
The Editors of *Rise Hvézd*
Royal Alfred Observatory, Mauritius
Royal Meteorological Society
Royal Observatory, Cape of Good Hope
The Editors of *Scientific American*
Service de Prévision Ionosphérique Militaire
Sociedad Astronómico de Mexico

Società Astronomica Italiana
K. Tekniska Högskolan, Stockholm
Union Radio Scientifique Internationale
United Nations Organization
United States Army Map Service
Universitätssternwarte, Innsbruck
University of California
The Editors of *Urania*
The Editors of *Vega*
World Calendar Association Inc.
Specola Vaticana

Professor H. Alfvén
Dr A. Armitage
Dr C. E. R. Bruce
Mr R. L. T. Clarkson
Dr A. K. Das
Executors of Mr M. E. Gheury de Bray
Mr A. Gjelsvik
Rev. A. Glazewski
Dr W. Gleissberg
Professor V. A. Heiskanen
Mr K. V. Hewitt
Professor M. A. R. Khan
Dr G. M. Lees
Dr F. C. Leonard
Mr H. A. Lloyd
Dr K. G. Meldahl
Sir Eric Miller
Mr S. Ocampo
Dr J. L. Pawsey
Dr L. Rodés
Professor Van Den Bergh
Professor M. Waldmeier

OBITUARY NOTICES

ERNEST ESCLANGON was born at Mison in Haute-Provence on 1876 March 17 and died at Eyrenville in the Dordogne on 1954 January 28. He was a member of l'Académie des Sciences and of the Bureau des Longitudes, and was President of the International Astronomical Union from 1935–1938.

He began his work in 1899 at the Bordeaux Observatory under the direction of G. Rayet, whose name is associated with the discovery of stellar emission lines. In 1904 Esclangon was awarded the degree of Doctor of Mathematical Sciences, with a thesis on quasi-periodic functions, functions which are encountered in the theory of perturbations and in several physical theories. As a lecturer at Bordeaux University he proved himself an excellent teacher.

The 1914 War revealed that the true vocation of this mathematical astronomer was as a physicist. He rapidly became one of the best-known experts on gun acoustics and projectiles. While attached to the Commission of Naval Artillery at Gâvres, near Lorient in Brittany, from 1915 to 1917, he made innumerable experiments, the results of which were published in a large volume in 1925. These researches contributed to the progress of an effective method of location by the sound of enemy guns. Esclangon had developed the principle in 1914 September. At the end of the war he was put in charge of the coordination of technical research in submarine warfare. Some months before his death he was still studying the sound phenomena produced by supersonic aircraft.

In 1919 he was appointed Professor at Strasbourg University and took charge of the re-organization of the observatory. The qualities he showed were to secure him in 1929 the directorship of the Paris Observatory, where he succeeded H. Deslandres; he held this post until 1944. He was appointed Professor of Astronomy at the Sorbonne in 1930, in place of H. Andoyer who had just died, and finally retired in 1946.

At the beginning of his career, Esclangon was an assiduous observer. His observations include eclipses of the sun, gravity measurements, and micrometer measurements of planets and comets. Later he was to devote the larger part of his scientific activity to directing the observatories in his charge. His work on adjusting an astrograph, calculating astronomical refraction, timing, and studying the distortions of meridian instruments is evidence of his constant care in perfecting the methods and instruments in the observatories. The installation of the speaking clock of the Paris Observatory was to bring him great popularity.

Like all good people of the Mediterranean he had a courteous and sincere manner; above all he loved to converse and he astonished his listeners by the wide variety of his interests. He died at the height of his intellectual powers after a short illness.

He was elected an Associate of the Society on 1932 June 10.

A. DANJON.

RICHARD SCHORR, who was Emeritus Director of the Hamburg Observatory and Professor of Astronomy in the University of Hamburg, died in Badgastein on 1951 September 21. His death was unexpected by all those who knew his extraordinary vitality, especially by his wife, his seven children and his grandchildren.

He was born in Kassel on 1867 August 20, passed his final examinations in Easter 1885, and from 1885 to 1889 studied in Berlin and Munich. Under the direction of Seeliger he took his doctor's degree on the movements of the triple system of ξ Scorpii. In the years from 1889 till 1892, Schorr was Assistant in Kiel to the publisher of the *Astronomische Nachrichten*, to the Observatory in Karlsruhe and to the Astronomisches Rechen-Institut in Berlin. When he was 25, C. Rümker, who was then Director of the Hamburg Observatory, made him an Observator. From that time the yearly reports of the Observatory show how he took on more and more administrative work from Rümker who was incurably ill, so that Schorr in fact was the leader of the Observatory. He was appointed Director of the Observatory in 1902 January 1 and occupied this post until 1941.

These 39 years cover an epoch of stormy development in our science. Immediately after his taking over the direction of the Observatory, he put all his energy into modernization. Moving the old Observatory from its position in Hamburg to 20 km away in Bergedorf meant in reality founding the Observatory afresh. His first plans were made before he was 30 years old and were strongly influenced by recent developments of ideas and astronomical techniques being made, particularly in the U.S.A. Nevertheless his wholesome appreciation of classical astronomy led him to erect the 19 cm meridian circle and to modernize the traditional time service. He gave special attention to a telephonic time signal which was introduced in 1907—the forerunner of the modern talking clock. In the first World War the Observatory took over the transmission of the first German wireless time signal, the instrumental design being made by Schorr and his colleague F. Dolberg. After the first World War the official time service was for the most part transferred to Government institutes.

Even under the difficulties of the first World War Schorr was able to publish the well-known *Hilfstafeln der Hamburger Sternwarte*. Under even more difficult circumstances he completed a thankless task which his predecessor left for him: the publishing of *Carl Rümkers Hamburger Sternverzeichnis* 1845 which came out in the time of the great money devaluation in 1922. In 1923 he financed the publication of the first edition of the *Eigenbewegungs Lexikon* with his own money and foreign subscriptions. A greatly extended edition of the *Eigenbewegungs Lexikon* appeared in 1936.

In 1928 Schorr, together with W. Kruse, published the *Index der Sternörter* 1900–1925 as a very useful sequel to the *Geschichte des Fixsternhimmels* which compiled star positions earlier than 1900. During the same period Schorr, on the request of Kapteyn, agreed to have the spectral types of more than 170000 stars in Selected Areas 1–115 estimated at the Hamburg Observatory. The instrument used was the Lippert-Astrograph which, on Schorr's initiative, was made a present to the Observatory by the wealthy Hamburg merchant Eduard Lippert. Under the authorship of A. Schwassmann who was responsible for the spectral types, and P. J. van Rhijn who determined the photographic magnitudes on plates furnished by Harvard Observatory, the five volumes of the *Bergedorfer Spektral-Durchmusterung* have been completed only recently.

Schorr's crowning success was the completion of the second AG-Catalogues. Planning began in 1921 and new instruments were designed. The observations were carried out in 1928–32. Measurements and reductions demanded some more years. In 1941 he took this work with him into retirement so that the last 10 years of his life were taken up with the final reductions, revisions and

supervision of the MS. for the photographic printing. He presented the first volume of the 10 volume Bergedorf series of the catalogue to the Astronomische Gesellschaft during its meeting in 1951 August. We were all impressed at that time with his deep sense of happiness which sprang from his satisfaction in the completion of his lifework. This happiness never left him in the last weeks before his death.

Schorr organized a series of eclipse expeditions. He was himself in Algiers in 1905, 1907 in Turkestan, 1914 in the Crimea, 1923 in Mexico, 1924 in the Atlantic, 1927 in Lapland. Also the expedition carried out by Baade and Schmidt to the Philippines in 1929 was prepared by him.

The name Schmidt brings us to Schorr's contact with this remarkable man to whom he gave the opportunity of developing from a lens maker, esteemed within a narrow circle of experts, to one of the greatest opticians since Fraunhofer and Abbé. The unstable, eccentric Schmidt would, without Schorr's guidance, which had to cover even the simplest things of daily life, scarcely have been able to concentrate on one definite abode or task.

The monumental results of Schorr's scientific activity are founded in his outstanding ability in organizing astronomical work on a large scale. The necessary team work was always inspired by his powerful optimism. He showed great care for all colleagues and subordinates. He never sought his own advantage at the cost of others, but was possessed of a great steadiness when it came to assisting a good cause or another individual.

He was elected an Associate of the Society on 1935 April 12.

O. HECKMANN.

SELIG BRODETSKY was born at Olviopol near Odessa on 1888 February 10. When he was very young his family escaped from Russia and settled in London. From the Central Foundation School he obtained a major Scholarship in Mathematics at Trinity College Cambridge, and was bracketed Senior Wrangler in 1908. As Isaac Newton Student he studied mathematical astronomy and took his doctorate at Leipzig in 1913. A lecturer in mathematics first at Bristol, he moved at the end of 1919 to Leeds, where he was almost immediately made Reader and in 1924 Professor of Applied Mathematics. For a period at this time he also conducted honours courses in applied mathematics in Edinburgh concurrently with his normal load of teaching in Leeds. He became head of the Mathematics Department in 1946 and retired in 1948. He was indefatigably helpful in all aspects of University life and development and in the Association of University Teachers, of which he served as President.

Brodetsky's main scientific pursuit was aerodynamics, on which he had collaborated in Bristol with G. H. Bryan. He published early in his Leeds days a series of papers on fluid flow and vortex motion; but his acknowledged mastery was of the dynamics of the aeroplane. His books include *A first course in nomography* (1920), *The mechanical principles of the aeroplane* (1921), and *Sir Isaac Newton, a brief account* (1927): the last of these was for the occasion of the tercentenary celebrations, in which he took an active and happy part. He wrote also on general relativity, and was early a vigorous exponent of that theory. His training had been largely in mathematical astronomy, and like his master, Sir Robert Ball, he did much for the dissemination of astronomical knowledge. He sensed the popular thirst for this knowledge in the years after each World War, and responded by

giving astonishingly comprehensive (and heavily attended) courses of extension lectures; in both post-war periods also he revivified the ancient Leeds Astronomical Society. His lectures on all occasions were memorable for their wealth and breadth of knowledge and for the homeliness, cogency and wit of his illustrations and asides.

A man of boundless energy, he worked and travelled prodigiously for Zionism, for the relief of Jewish refugees, and for the promotion of Jewish education. He was intimately concerned in the establishing of the Hebrew University of Jerusalem, and in 1949 became its President. Ill-health, accentuated by the difficulties of the University, necessitated his return to this country in 1951. Despite his failing of bodily vigour, he continued his labours for his cherished causes with his spirit and keenness of mind unabated. His death on 1954 May 18 was felt as a personal loss by thousands. He is survived by his wife, his son and daughter.

He was elected a Fellow of the Society on 1910 April 8.

N. B. SLATER.

FREDERICK RICHARD CRIPPS died on 1954 January 29 in his 85th year. He was educated at Haberdasher's Aske's School, and subsequently joined the Civil Service, serving for the greater part of his life on the staff of the Supreme Court Pay Office. His interest in astronomy was late in developing, and it was not until his return from the Boer War (in which he had served with the City of London Imperial Volunteers) that he began to show that flair for computing that was later to establish his reputation. He joined the British Astronomical Association in 1904, and in 1907 was one of the three computers who assisted Cowell and Crommelin in their classic study of the motion of Halley's Comet. A succession of papers in Volume 68 of *Monthly Notices* shows how this arduous labour progressed, revolution by revolution, until the calculations were eventually linked with the early Chinese observations of 240 B.C. The influence of this early training and of the long association with Crommelin is evident in all of Cripps' subsequent work; he became a specialist in computing perturbations, and took infinite care to ensure that his results were thoroughly reliable.

Cripps was elected a Fellow of the Society in 1908, and in 1909, with Crommelin's assistance, computed his first definitive orbit, based on more than 200 observations of Comet Daniel. He became better known to comet workers after 1922, when the first *B.A.A. Handbook* was published. From that time on, he took a leading part in the annual predictions of the returns of periodic comets, and after his retirement in 1931, not a year passed without the publication of at least one of his carefully computed orbits.

Failing eyesight compelled Cripps to relinquish this work in 1950, and in that year he was awarded the Walter Goodacre Medal and Gift of the British Astronomical Association for his outstanding services in the field of computing. The award gave him much pleasure, and did something to reduce his disappointment that, at the age of 80, he was compelled to abandon his hobby.

In his early days Cripps had none of the modern aids to computing and, indeed, to quote his own words, he always preferred the quiet rustle of the

leaves of a book of logarithms to the noise of a calculating machine. Methods change, but there is only one standard of computing, and from that standard Cripps never faltered.

J. G. PORTER.

INIGO OWEN JONES was born in Croydon on 1872 December 1. His parents took him to Queensland in 1874 and he was educated in Brisbane and joined the Queensland Weather Bureau, where he was strongly influenced by the late Clement Wragge. On 1893 February 2 he observed the Australian record rainfall of 35¾ inches in 24 hours, at Crohamhurst, about ten miles from the hamlet of Beerwah, itself forty miles north of Brisbane; and at Crohamhurst, Inigo Jones ultimately settled and devoted himself to the attempt to produce long-range weather forecasting. As this is of vital interest to the Australian agricultural community, Inigo Jones was able to find support for a special institution, the Crohamhurst Observatory, of which he was Director, and which issued forecasts. These were based on cycles which were looked for in rainfall records, the periods especially examined being twice the orbital periods of Jupiter and of Saturn: and the influence of sunspots was also sought. To these ideas, which might appear to the orthodox to offer little promise of success, Inigo Jones remained faithful. In his own opinion he achieved something, but of this he was unable to convince any substantial body of Australian scientific opinion. He had a very considerable following of farmers and graziers. In his later years he was something of a legendary figure in scientific circles, as his ideas were well known; but as Crohamhurst is remote, even by Australian standards, he was seldom seen.

Besides his meteorological forecasting, he carried on stud cattle breeding a Crohamhurst. He married Marion, the daughter of James Comrie, in 1905, and had four daughters. He became a Fellow of the Society on 1935 April 12, and died on 1954 November 15.

R. v. d. R. WOOLLEY.

MICHAEL STEPHANOVITCH KOVALENKO was born in Taganrog, Russia, on 1888 November 20. He received degrees at the St Petersburgh Institute of Technology in 1912, and at the University of Paris in 1924. From 1924 to 1926 he participated in the research work of the McCormick Observatory at the University of Virginia. He obtained his Doctor's degree at Princeton University in 1927, after which he held the position of Assistant Professor of Mathematics and Astronomy at Swarthmore College from 1927 until his retirement in 1939. He was engaged in research at the Sproul Observatory of Swarthmore College, and published several papers on parallaxes, mass-ratios, and proper motions.

In 1946 he established the Jessie Stevenson Kovalenko Scholarship for astronomy students, or graduates, of Swarthmore College. This was one of the many memorial funds he established in memory of his wife, who died in 1943.

He was elected a Fellow of the Society on 1928 November 9, and died on 1954 April 2.

PETER VAN DE KAMP.

HENRI MINEUR was born in Lille in 1899 where his father taught mathematics. While still very young he showed a remarkable aptitude for the study of this science, and at the age of 18 passed first into the Ecole Normale Supérieure. After an interruption of two years in his studies, during which time he joined the army for the First World War, he passed brilliantly in the Concours de l'Agrégation in mathematical sciences. After being appointed Professor at the Lycée Français in Dusseldorf he prepared his doctorate thesis on " Discontinuous solutions of a class of functional equations ".

While still young Henri Mineur showed a lively interest in astronomy. In 1925 he entered the Paris Observatory as an "astronomer adjoint". In 1936 two successive Under Secretaries of State for Scientific Research gave their support to Henri Mineur by the creation of the Institut d'Astrophysique in Paris, the Observatory in Haute Provence and the *Annales d'Astrophysique*. Mineur was appointed director of the Institut d'Astrophysique. He was thus able to play a leading part in rousing a renewed interest in French astronomy.

Henri Mineur's researches in the world of astronomy covered a wide field: relativity, evolution of double stars, the mechanics of variable masses, the study of stellar motions, interstellar absorption and celestial mechanics. During the latter years of his life he devoted himself especially to the study of methods of numerical computation.

Henri Mineur played an active role in the Second World War, partly in the army, partly in the Resistance movement and also partly in the organization and direction of a computing office for National Defence.

He died suddenly on 1954 May 7.

He was elected a Fellow of the Society on 1933 April 12.

D. BARBIER.

EDWARD O'CONNOR was born at Port of Spain, Trinidad, 1874 November 26, and received his early education there; he completed his schooling at Beaumont College, Old Windsor. At the age of 19 he entered the Jesuit order, and five years later went to Campion Hall, Oxford, where he took a double first in Mathematics. In 1902 he began his long association with Stonyhurst College and Observatory, being appointed lecturer in Mathematics to the Jesuit students whose philosophate was at that time at St Mary's Hall, Stonyhurst. These students ran a small observatory which was then collaborating with the College in obtaining photographic spectra of γ Cas. His inevitable connection with this work stimulated his interest in observational astronomy. Accordingly, when he returned to Stonyhurst after his ordination, he combined teaching mathematics with the post of Assistant Director of the Stonyhurst Observatory. In 1914 he accompanied Fr Cortie to Hernösand in Sweden to observe the solar eclipse. On his return he found the additional jobs of Choir Master and Director of Music laid at his door! This is a trivial instance of the way in which, all through his life, his breadth of character and talent were to force him to put the service of others before personal achievement.

In 1916 he was appointed Rector of Stonyhurst. He held this post till 1924 and a year later succeeded Fr Cortie as Director of the Observatory. He attended the I.A.U. Assembly at Leyden in 1928 and the following year visited

several European observatories. His hope was to develop and modernize solar observational work at Stonyhurst. Good progress had been made on the construction of a spectroheliograph, when he was again appointed Rector. This renewed appointment, of which there is only one other instance in the long history of the College, lasted until 1938. Thus ended his long connection with Stonyhurst. In the early years of the war, while again tutoring Jesuit students in London, he was also engaged in high-altitude wind researches for the War Office. In spite of poor health and failing sight he continued his teaching work almost till his death in his eightieth year.

To those who knew only Fr O'Connor's enthusiasm for astronomy this account may depict a life of scientific frustration. Yet one had only to meet him in his later years to realize that a less frustrated man would be hard to find. He had a finely integrated character, at once humanist, scientific and religious. He had many interests, and what is rarer, many competences, and seemed to know how to bring the accuracy, severity and specialization of science to all his activities without detriment to their proper genius. An occasion comes to mind when he was called to drill a hastily composed choir for the plain-song of the "Tenebrae" service of Holy Week. If his demands and expectations seemed rather high, yet his occasional demonstrations of "what he wanted"—little masterpieces of interpretation in a beautifully controlled tenor voice—left his choir no doubt that they were in good hands. He gave one the impression of being not merely on top of his work but in charge even of his enthusiasms; he was always more than the sum of his interests and enthusiasms. He brought to everything a personal charm and gaiety as well as a strong will and uncompromising standards. The writer, who studied mathematics under him and assisted him in his meteorological work, can say that his only fault, if fault it was, lay in expecting his students to work as hard as he did! His astronomical work, and indeed his whole life's activity, was of that anonymous kind associated with teaching and administration. He did not mind this; he enjoyed working with and for other people.

Fr O'Connor became a Fellow of the Society on 1914 January 9. He died on 1954 February 23 after a short illness.

P. J. TREANOR.

ROBERT FERMOR RENDELL was born on 1873 October 14. He was educated at the Roan School and from 1892 to 1903 was a computer at the Royal Observatory, Greenwich. He left Greenwich to become First Assistant at the Durban Observatory. However, he was a man of strong religious convictions, ever an active church worker and in 1907 he reliquished his astronomical position to enter the church. He took orders, became Curate at Barrow-in-Furness and later the Rector of Brightlingsea, Essex. He was married and had one son and two adopted daughters.

He became a Fellow of the Society on 1896 February 14 and died on 1954 April 18.

PROCEEDINGS OF OBSERVATORIES

Royal Greenwich Observatory

(Director, Sir Harold Spencer Jones, F.R.S., Astronomer Royal)

Meridian department.—Observations with the Airy Transit Circle were terminated on 1954 March 30, so ending the unique series of fundamental observations extending over 103 years with this telescope which, by international agreement, defines the zero of longitude. The old Observatory buildings at Greenwich, as they are vacated by the transfer of departments to Herstmonceux, are being handed over to the National Maritime Museum, to form an Annexe of Astronomy and Navigation. The old instruments of the Observatory, up to and including the Airy Transit Circle, will remain at Greenwich where they can be seen by the public.

Before the instrument was taken out of use the following observations were made :—

Sun	28	Jupiter	13	Ceres	1
Moon	18	Saturn	1	Pallas	3
Venus	4	Uranus	8	Juno	4
Mars	1	Neptune	1	Stars	280

The cessation of current observational reductions is providing an opportunity to overtake some of the arrears of computing.

The Cooke Reversible Transit Circle, which now becomes the fundamental instrument of the Observatory for meridian work, is being erected at Herstmonceux. All of the massive parts are in position in the new pavilion and work on the more detailed components is proceeding. The adaptation of the circle reading microscopes to photographic recording is nearing completion, including the necessary apparatus for advancing the films and making the exposures for the two sets of cameras from central control positions. Active consideration is being given to the design of a machine for measuring the photographic records from the circle cameras.

The change to photographic recording of the circle readings made necessary a number of modifications to the eye-end of the telescope. An automatic printing Z.D. micrometer head has been obtained from the Imperial College of Science and Technology and adapted to the Cooke instrument. New R.A. micrometer contact wheels have been fitted to enable chronographic records to be made with a projected phonic motor chronograph, to be installed when the quartz oscillator clocks are in operation at Herstmonceux.

A small defect in the silvering on the glass fixed circle of the Cooke transit circle, which would interfere with the photographic recording of the circle graduations (the cameras cover a larger field than the visual microscopes), was eliminated by dissolving the silver coating from the region of the blemish and resilvering this small area.

A study of the methods that have been used to determine flexure suggested that an improvement might be made if an " optical square " were mounted in front of the lens, so that a star could be observed at telescope-positions differing from the direct one by $\pm 90^{\circ}$. This should separate refraction from flexure, and should permit determination of second and third harmonics in the latter. An optical square of four inches clear aperture has been obtained, in fused quartz, and will be mounted on the Cooke T.C. to study the method in practice.

The erection of the new Photographic Zenith Tube was commenced in November.

Time department.—Astronomical observations for time determination have continued throughout the year at Greenwich and Abinger. At Greenwich Small Transit C was transferred on January 1 from the Altazimuth Dome to the Courtyard Dome, where it has served as a standard instrument throughout the year. At Abinger observations were made throughout the year with the Bamberg Broken Transit. The total number of observations used was 424, of which 252 were obtained at Greenwich on 168 nights and 172 at Abinger on 107 nights.

The four-point-supported GT-cut crystal referred to in the previous report was received from the Post Office Laboratories in February and was incorporated in oscillator D6. The ring crystal B5 was returned on May 25 after investigation, and is now performing satisfactorily. The GT-cut crystal from the experimental oscillator G2 has been transferred to D cellar where it is now incorporated in D4, and a further GT crystal was obtained from the Post Office on December 20 and set going in oscillator D5. It is planned to transfer this latter crystal to the Clarendon Laboratory, Oxford, where its performance at low temperatures will be investigated.

Time signals have been received throughout the year from Australia, Canada, France, Germany, Russia, South America, and the United States of America. The time signals superimposed on the MSF (British) and WWV (U.S.A.) standard frequency transmissions have been regularly compared with the Observatory standards, together with the frequency comparisons on the MSF and Droitwich carriers.

Under the auspices of the C.S.A.G.I. a special programme of radio reception and measurement was arranged during the week ending December 18, with a view to introducing a regular programme of measurements of the time of propagation of time signals by duplex transmissions. The Royal Observatory cooperated in the preliminary series and the results have been forwarded to the Director, Instituto Elettrotecnico Nazionale, Turin, for collation with the data received from the other co-operating stations.

Radio time signals controlled from the Royal Observatory have been radiated according to the normal schedule with the addition of a special transmission on June 30 extending over six hours, together with the rehearsal signals on the preceding days, for use by observers of the solar eclipse.

There have been no major changes in the operational equipment of the Time Service, but a number of new units have been designed and are under test in order that experience may be gained prior to the preparation of final designs for the new installation at Herstmonceux.

Astrometry and Astrophysics department.—The 13-inch astrographic refractor has again been used for photographing the brighter minor planets : 9 plates of Juno, 13 of Pallas, 14 of Ceres and 16 of Vesta were secured during the year. Tests of the effect on astrometric places of exposing at large hour angles

have been continued on a circumpolar field (51 plates) and on an equatorial field (32 plates); measurement of these is proceeding. The minor planet Nemausa was photographed on 15 occasions, and some test exposures were made through the glass in connection with a proposed programme for measuring proper motions of certain red variables.

Observations have been continued of the spectra of the standard stars of the Yerkes Atlas, and of other fainter stars, on the single-prism spectrograph attached to the 36-inch Yapp reflector. In spite of the fact that no observations were possible until April 26, owing to work on the 21-ft eclipse telescope, 103 spectrograms of 84 stars were secured during the year. During the period when the telescope was out of use for spectroscopy it was employed by Mr F. J. Hargreaves in an attempt to televise Jupiter and its satellites. A B.B.C. television camera with its lens turret removed was installed at the Cassegrain focus behind a Barlow lens. A successful preview transmitted at the end of broadcasting on January 13 included excellent views, at various magnifications, of the planet and its Galilean satellites, and of the Moon. Unfortunately, the full-scale programme arranged for the next night was clouded out, and a stand-by programme using photographs and models had to be substituted. At the end of December the 36-inch mirror was dismounted and sent to Messrs Cox, Hargreaves & Thomson for re-figuring prior to removal of the telescope to Herstmonceux.

Eclipse of 1954 *June* 30.—Tests at Greenwich on the 21-ft refractor mounted on the field equatorial mounting were completed on April 26 and the instrument was dismantled and transported to Sweden. It was re-erected on the island of Syd Koster, near Strömstad, under cover of a tented framework of aluminium scaffolding. Thin cloud at the time of the eclipse prevented the recording of any of the stars needed for determining the Einstein displacement. However, the single photograph taken, though heavily fogged by coronal light scattered in the cloud which covered both the eclipse field and the comparison field, gives an excellent picture of a typical minimum corona.

The two expeditions to Sweden for the determination of the Moon's place for geodetic purposes were unsuccessful because of cloud. One expedition stationed just outside the zone of totality was to have observed by the Atkinson method, and the other, stationed near the central line, was to have observed by the Banachiewicz method. It had been hoped by these observations to obtain a direct comparison of the relative advantages and accuracy of the two methods.

Eclipse of 1948 *November* 1.—The final paper on the Mombasa eclipse work has been completed; the internal probable errors correspond to ± 34 metres and ± 45 metres (measured parallel to the fundamental plane) for the geodetic uncertainty of the station, or to $\pm 0''{\cdot}020$ in α and $\pm 0''{\cdot}025$ in δ for (roughly speaking) the difference between the Moon's place and the Sun's. The Moon's absolute place appears to be in good agreement with that obtained by interpolating annual means of occultation results.

Solar department.—The Sun was photographed at Herstmonceux on 299 days. Up to November 30 no day is unrepresented in the combined Greenwich–Cape–Kodaikanal series. Cape negatives in duplicate have been received up to 1954 September 29.

The measurement of the combined series of photographs has been made from 1953 May 17 to 1954 August 3. Tables of the mean daily areas and mean

latitudes of sunspots for each solar synodic rotation for 1949 and 1950 have been published in *Monthly Notices*, and the data for 1951 and 1952 are in course of publication. The *Greenwich Photoheliographic Results* for 1942, 1943 and 1944 have been issued during the year.

The Sun's disk was observed in Hα on 137 days. On 51 days observations were restricted to 15 minutes or less.

Measures were made on 28 dark flocculi and 22 on normal bright flocculi for the presence of radial motions.

Only one minor flare was observed at Herstmonceux during the year. This was associated on March 1 with a small sunspot of the new cycle. No measurable effect, however, appeared on the S.E.A. recorder, working on a wave-band around 27 kc/s and, in fact, no indication of a flare appeared on this recorder throughout the year, which was a year of minimum sunspot activity.

Varityper copy is in preparation of a small volume to be published in 1955 with the title " Greenwich Sunspot and Geomagnetic Storm Data, 1874 to 1954". It will include monthly mean daily areas of sunspots and faculae: sunspot latitude data, including Maunder's " butterfly " diagram brought up to date: a catalogue of sunspots (numbering 760) of mean area $\geqslant 500$ millionths of the Sun's hemisphere: catalogues of great and of small geomagnetic storms, together with a catalogue of earlier great storms 1840 to 1874.

The construction of the Evershed solar spectrograph installation has continued. The train of three solid glass prisms has been received back from Messrs Hilger, after being re-figured and tested by an interference method over the whole aperture. Both this train and the train of three large liquid prisms have been subjected to tests in the spectrograph cellar, in order to determine their performance and the conditions necessary to yield that performance. Constructional work on the coelostat and secondary mirror is not yet complete.

A birefringent monochromatic filter, of the type designed by Lyot for Hα photography, has been received from the makers, Optique et Précision de Levallois. It appears to be of high quality. This filter has a pass-band of 0·75 A and can be tuned over a range of ±1 A. The construction enables the filter to be used for whole-disk photography of the Sun's disk in Hα light with a 6-inch telescope. Some provisional photographs have been taken using a small coelostat but it is intended that the filter shall be fitted to the Newbegin 6¼-inch refracting telescope and used for routine photography and the photometry of details on the Sun's disk visible in Hα light. The mechanical and optical parts required are nearing completion.

Cosmic rays.—Observations of the Cosmic Ray flux have been carried out throughout the year. The recording was done with CINTEL apparatus, counting the entire ionizing flux crossing an area of about 7000 cm². The barometric and temperature coefficients were obtained from the data, and the remaining variations of the intensity were analysed. A diurnal effect of unsteady phase was observed; but the low intensity of solar activity precluded other effects.

In order to comply with the recommendations of I.U.P.A.P. for a world-wide network of comparable observing apparatus, modifications are being carried out to remove the electron flux from the count, and to narrow the angle of acceptance around the zenith.

Nautical Almanac Office.—The 1955 editions of the annual publications of the Office and the four-monthly parts of the *Air Almanac* for 1954 September to 1955 April have been published during the year; no changes have been made in

these publications. The editions for 1956 are at various stages of publication. All other work of the Office, including occultations, has been continued.

For the first time the copy for one of the annual publications, namely *Apparent Places of Fundamental Stars* for 1956, was prepared on the card-controlled typewriter. It has been possible to do this without making any significant changes in the form of presentation.

The Joint Supplement to the *American Ephemeris* and the *Nautical Almanac*, referred to in last year's report, has been prepared jointly under the title *Improved Lunar Ephemeris, 1952–1959*. The calculation of the tables for this publication was completed, and the copy prepared on the card-controlled typewriter; it is being printed in the United States of America. In addition to the longitude, latitude and horizontal parallax of the Moon at half-daily intervals, supplied by Dr W. J. Eckert, the tables contain the apparent right ascension, to $0^s{\cdot}001$, and declination, to $0''{\cdot}01$, at hourly intervals; there are also included, for the same period, the fundamental daily values of the nutation in longitude and obliquity, and of the aberrational day numbers C and D, calculated on the new basis. The volume also contains full descriptions of the construction of the lunar ephemeris (by W. J. Eckert and collaborators), of the comparison of the ephemeris with Brown's *Tables* (by E. W. Woolard) and of the methods used for the subtabulation to twelfths (by A. E. Carter) and for the calculation of the nutation (by G. A. Wilkins).

The preparation has been completed of the first part of the *Nautical Almanac* 1960 in which are introduced all the changes recommended at the 1952 (Rome) meeting of the International Astronomical Union. The design and contents have been agreed generally with the other ephemeris offices and, in view of conformity with the *American Ephemeris*, in some detail with the Director of the U.S. Nautical Almanac Office.

Agreement has been reached that, beginning with the 1960 editions, the *American Ephemeris* and the *Nautical Almanac* shall be, apart from a few introductory pages, identical publications. The first part of the Almanac will be the responsibility of H.M. Nautical Almanac Office and the second part the responsibility of the U.S. Nautical Almanac Office. Both parts will be set in type and reproduction proofs interchanged between the Offices; the two almanacs will then be printed by photolithography from identical material. They will be published separately in the United States of America and in the United Kingdom, and will maintain their separate identities. The reproduction proofs will be made available to other ephemeris offices who wish to make use of them.

This "conformity" of the two publications will involve no substantial change of content or arrangement but should result in a considerable reduction in the price. It should also prove to be a step towards still wider international co-operation in the field of astronomical ephemerides.

It has been decided to produce copy for the *Abridged Nautical Almanac* on the card-controlled typewriter as from 1958; specimen pages, acceptable to representatives of all users, have already been prepared and final details are under consideration. No alteration of principle and little of arrangement is involved.

General.—The construction of the Equatorial Group, to house three refractors and three reflectors, is well advanced. The construction has been commenced of the West Building, which will accommodate the Time Department, the Nautical Almanac Office, and the workshops, and will include space for storage of publications, spare instruments etc.

Royal Observatory, Edinburgh

(Director, Professor W. M. H. Greaves, F.R.S., Astronomer Royal for Scotland)

Stellar spectrophotometry.—The results for seven stars of spectral type B1 are in the press and will appear as *Publications of the Royal Observatory, Edinburgh*, Vol. **1**, No. 6. Work is in progress on the reduction and analysis of eleven stars of Draper Type B0 and of eight stars of type O. Some results have already been published for seven of these type O stars (*Publications of the Royal Observatory, Edinburgh*, Vol. **1**, No. 2) but the continua originally adopted are being revised and additional lines have been measured. The measurement of the spectra of 20 stars of Draper types B2 and B3 is proceeding; the scheme of measurement has been amplified and these B2 and B3 negatives are being measured at about 2300 wave-lengths. It is hoped that the present scheme can be used without further modification for the remaining stars of type B.

During the year a paper by Dr R. Wilson, "The Ionized Helium Series originating from the Fifth Quantum Level", has been published (*M.N.*, **113**, 557; *Edinburgh Communication* No. 7).

The overhaul of the 36-inch reflecting telescope, the commencement of which was reported last year, has been continued and is now nearly complete. Most of the wiring has been renewed and the use of slip-rings has been largely eliminated.

An E.M.I. photo-multiplier cell has been fitted to the Hilger spectrograph so that it receives all the starlight reflected from the first face of the first prism. It is proposed to integrate the output current from this cell during an exposure with the telescope and spectrograph. The cell will thus function as an exposure meter. Even in its present state (i.e. used only as an intensity indicator for the light transmitted through the slit) it materially assists the observer both in assessing time of exposure and in guiding.

Solar work.—The Sun was observed on 92 days; observations were made in Hα light on 87 of these and 39 disk drawings were made in white light on days when there were any sunspots to record. No flares were observed during the year, an indication of the exceptionally low level of solar activity.

The recorder, which shows the integrated level of radio atmospherics on a frequency of 24 kc/s, was kept in continuous operation, but no sudden enhancements of atmospherics (S.E.A.s) were recorded. The absence of these sudden ionospheric disturbances due to flares is further confirmed by the fact that no short-wave fade-outs were reported by Cable and Wireless Limited during 1954. The yearly numbers of S.E.A.s recorded at Edinburgh since 1950 have been as follows:—

Year	1950	1951	1952	1953	1954
S.E.A.s	82	81	22	7	0

Work was begun on the construction of a direct recording variometer for the horizontal component of the Earth's magnetic field. This incorporates a magnetograph, two R.C.A. 931-A photocells and a Cambridge thread recorder; the object is to provide immediate information of the occurrence of geomagnetic crochets (solar flare effects) and of magnetic disturbances (solar particle effects).

Twenty-eight calibrated plates of prominence spectra were obtained with the combined spectrohelioscope and spectrograph. The plates include the lines Hα to Hε of the Balmer series and the *H* and *K* lines of Ca II. Microphotometry of these plates, along with those obtained in the previous year, has been completed and the reduction and discussion of the results is now in hand.

The analysis of photoelectric measurements of the solar *K*-line made by Dr M. J. Smyth and mentioned in the last report, has been concluded. The results confirm that after moderately intense solar flares, absorption in the violet wing caused by particles approaching with speeds between 750 and 1150 km/sec is less than one-half per cent. There is also little evidence of absorption of this magnitude associated with sequences of recurrent geomagnetic storms. The results have been communicated to the Society and are in the press.

Solar eclipse.—Dr M. A. Ellison took part in the Auroral Zone Eclipse Flight on 1954 June 30 (see account in *The Observatory*, **74**, 246, 1954). The photographs of the corona taken on that occasion with Leica cameras at a height of 8500 feet (with the co-operation of Mr G. V. Black) have been examined with the Kipp Star Actinometer. In the best defined exposure ($\frac{1}{20}$ sec at $f/2{\cdot}0$ on Ilford HP3 film) the great equatorial extensions can be traced quite certainly to 8 solar diameters from the Sun's centre on the E side and to 6 diameters on the W side. Visual estimates made during totality were 4 diameters and 3 diameters respectively. Observation through a sheet of high quality polaroid filter showed that both these " rays "disappeared at one setting of the polaroid for all distances beyond about 1 diameter from the solar limb.

Observation of the Sun in Hα light on the day previous to the eclipse (June 29, 10^h U.T.) showed only two faint prominences ($+35°$ E limb and $+34°$ W limb) and one small dark filament near the central meridian at $+38°$. No sunspots were present on the disk during the interval June 3 to July 2. We may conclude that the white corona seen at this eclipse approximated, as nearly as has ever been observed, to the minimum type—the completely quiescent state, in which the shape is uninfluenced by centres of sunspot and prominence activity.

Schmidt telescope.—Photographs taken in the early part of the year indicated that on some occasions the films were not in perfect register at all points with the focal surface. During the summer, therefore, one of the film holders was returned to Messrs Cox, Hargreaves and Thomson Limited, who undertook to modify and strengthen it, for use with circular glass plates, in preference to films, for photometric work. The modified plate holder now appears to be entirely satisfactory for this purpose, and the programme of photometric work on selected galactic clusters has been resumed.

Clocks.—The mean-time clocks, Riefler 258 and Leroy 1230, have maintained excellent rates during the year. The Shortt 4 (sidereal time) slave mechanism was overhauled at the Chronometer Repair Department, Royal Greenwich Observatory, and new platinum contacts were fitted. Since its return it has been operating satisfactorily the repeater dials throughout the building, and the master movement of the same clock has been sent to Herstmonceux for a similar overhaul.

Seismology.—Our thanks are due, as in former years, to Mr E. Tillotson for undertaking the reading of the Milne-Shaw seismograms and for answering correspondence relating to them.

Visitors.—Visiting scientists during 1954 included Professor V. A. Ambartsumian, Dr W. N. Christiansen, Dr F. Gondolatsch, Professor R. O.

Kapp, Dr D. W. N. Stibbs and Dr R. v. d. R. Woolley. We were also pleased to welcome a visiting party from the Astronomical Society of Glasgow.

Personnel.—Dr M. J. Smyth has resigned his post as Lecturer in Astronomy in the University of Edinburgh to take up the post of Chief Assistant at Dunsink Observatory. He has been succeeded by Mr V. C. Reddish.

Royal Observatory, Cape of Good Hope
(*Director, Dr R. H. Stoy, H.M. Astronomer*)

Reversible Transit Circle.—The observations for the *Second Cape Catalogue for* 1950·0, which were begun in 1951, were continued. This catalogue contains approximately 6800 stars and includes 604 FK3 stars, all stars in the G.C. brighter than $8^m{\cdot}5$ between declinations $-30°$ and $-52°$ and between $-80°$ and $-90°$, and other stars south of $-80°$ which have been specially selected to serve as standards for the reduction of the photographic zone observations. The stars south of $-80°$ have received preferential treatment and the observations of them have been completed.

During 1954 a total of 9233 transits were observed. This includes 307 observations of stars during the daytime and the following observations of bodies in the solar system :—

Sun	127	Mars	24	Vesta	7
Moon	46	Jupiter	11	Juno	18
Mercury	51	Saturn	21	Pallas	25
Venus	75	Uranus	27	Ceres	28
		Neptune	22		

Cape Photographic Catalogue for 1950·0.—Work on this project proceeded steadily. The volume covering the first zone ($-30°$ to $-35°$) was published during the year. The introductions for the next two volumes ($-35°$ to $-40°$ and $-52°$ to $-56°$) were completed and it is hoped that both these volumes will be published in 1955. The computations for the $-56°$ to $-60°$ zone were completed and a start made with writing out the copy for press. The final typescript for the zone $-60°$ to $-64°$, which it is intended to publish in the same volume, was completed in 1953.

Parallax programme.—The observations for the main part of this programme were completed in 1951 but a few extra stars have since been added to the working list at the specific request of individual astronomers. During 1954, 358 plates were taken, of which 44 were for parallax and the remainder for the determination of proper motion. 896 plates were measured and parallaxes derived for 26 stars, for 22 of which a parallax had not previously been determined at the Cape.

Eros.—At its 1954 opposition, Eros was too far south to be observed conveniently from observatories in the northern hemisphere. An attempt was therefore made to observe it approximately every fourth day between January 28 and July 28. 46 plates of it were taken with the Victoria Telescope, each plate normally receiving four exposures. By the end of the year, half of the plates had been measured. About 12 reference stars per plate are being used to reduce the effect of inaccuracies in their proper motions, since none of the catalogues from

which they were selected—the Cape Astrographic Zone Catalogues, the Yale and Cape photographic catalogues—are of sufficiently recent epoch for the effect of such errors to be ignored.

Proper motions.—The 1953 Groningen Conference recommended that existing astrographic material be used for finding the proper motions of selected objects and of all stars in specific areas. 136 of the list of variables compiled by Dr Plaut have been identified on plates taken over fifty years ago and a detailed working list of the modern plates required has been compiled. Also included in this working list are the plates required to give proper motions in regions surrounding galactic clusters and Kapteyn Selected Areas 164–187. Special attention is being given to Areas 172, 173, 179 and 180. 71 plates taken through the glass were obtained for this programme during 1954.

Radcliffe section.—The weather at Pretoria was again rather disappointing, only about 60 per cent of the time with the Radcliffe Reflector allotted to the Cape being suitable for observation. The principal effort was directed to the radial velocity programme begun in 1951. 487 spectra were obtained and 490 measured during the year. Data are complete for many of the stars and it is hoped to have the whole programme substantially completed in 1955. Spectral types on the MK system have been estimated for those stars for which a final velocity has already been derived. 85 direct photographs were taken at the Newtonian focus. These were partly photovisual plates of Kapteyn Selected Areas and partly long-exposure plates of the larger extra-galactic nebulae. In particular, plates were obtained for a population study of NGC 55 and NGC 300. 490 photoelectric observations were made with the Cassegrain photometer, mainly of fainter stars in the E regions.

Stellar photometry.—An ultra-violet colour index has, in the past few years, become recognized as an important parameter for distinguishing certain effects due to differences in absolute magnitude and interstellar reddening. A knowledge of this parameter also enables a more accurate conversion to be made from one photographic magnitude system to another containing a different proportion of ultra-violet light. Observations made by Dr Code and Mr Houck of the Washburn Observatory during their visit to the Cape in 1953 showed that sufficient ultra-violet light is transmitted by the 24-inch lens of the Victoria Telescope to make three-colour (U, B and V) photometry practicable. Suitable ultra-violet and ultra-violet cut-off filters were therefore obtained for the photometers attached to the Victoria and Astrographic Refractors and a number of short semi-experimental programmes of ultra-violet observations have been started. It is not intended to exploit such observations to any large degree until the photometric possibilities of the 18-inch Reflector have been explored. This reflector was ordered in 1953 and it is hoped that it will be delivered in time to bring it into use during 1955. The refractors will probably give the more stable colour system, but the perfect achromatism and the relatively high proportion of ultra-violet light reflected by the aluminized mirrors should make the 18-inch Reflector more suitable for three-colour photometry.

The three programmes involving the observation of ultra-violet light which have been started are (i) three-colour observations with the Victoria Refractor of the B-type stars, of which the radial velocities and spectral types have been determined at the Radcliffe Observatory, together with a selection of the stars observed by Johnson and Morgan, (ii) two-colour observations (U and B) of stars

brighter than $7^m{\cdot}0$ in the nine E regions and of stars brighter than $3^m{\cdot}5$ distributed over the whole sky. These observations are being made with the Astrographic Refractor and special attention is being paid to the constancy of the zero point from region to region, (iii) three-colour observations with the Victoria Refractor of stars brighter than $10^m{\cdot}0$ in the nine E regions.

461 observations were made for the first of these programmes in 1954 and 1034 for the second. The third of these programmes is part of a larger one which includes E-region stars between the seventh and twelfth magnitudes. Stars brighter than $10^m{\cdot}0$ are being observed in three colours, those fainter than $10^m{\cdot}0$ in two colours (B and V) only. The object of this programme is to strengthen the existing data for these stars, to remove any scale errors that may still remain in the 1953 S System and to provide a firm overlap with the observations of still fainter stars which it is hoped to make at the Radcliffe Observatory. 1552 observations were made for this programme during the second half of 1954 and errors affecting the zero point of the S magnitudes by about $0^m{\cdot}01$ at the eleventh magnitude were detected in some of the regions.

Work on the " Bright Star Programme " which was begun in 1953 continued steadily throughout 1954, and 3014 observations were made. This programme includes all stars in the Yale Bright Star Catalogue between $-4°$ and $-64°$ together with a number of fainter stars from the radial velocity and parallax lists. Observations are being made in two colours (B and V) with the photoelectric photometer attached to the Astrographic Refractor. By the end of 1954, magnitudes and colours had been derived for over 200 stars which had been observed four or more times. The internal standard errors of the means are $\pm 0^m{\cdot}006$ for the colours and $\pm 0^m{\cdot}008$ for the blue magnitudes. The size of these errors is an independent indication of the homogeneity of the magnitudes and colours given in Cape Mimeogram No. 1 which were used as standards, since only in relatively rare cases will the individual observations of any particular star depend on the use of the same standards. Another point that came out clearly in the course of the reductions is the relative stability of the colour characteristics of the refractor–photometer combination, a stability that reflectors do not appear to possess to anything like the same degree.

The Photometric Cameras were used to obtain 112 pairs of plates for the programmes begun in 1952 December. The first of these programmes is intended to provide photographic and photovisual magnitudes for the 9400 stars between $-64°$ and $-72°$ that are to be included in the Cape Photographic Catalogue for 1950·0. The second aims at comparing the nine E regions at $-45°$ with the 12 C regions and the 24 Kapteyn Selected Areas at $+15°$. 5800 images on 10 pairs of plates were measured with the Schilt Photometer for the first of these programmes and 11 400 images on 29 pairs of plates for the second. The stars being measured in the Selected Areas at $+15°$ are those which Professor Redman and Dr Beer compared directly with the North Polar Standards when the Photometric Cameras were on loan to the Cambridge Observatories.

Mr Houck of the Washburn and Harvard Observatories worked at the Cape for two weeks during February to round off the series of three-colour observations of O and B stars he had made here during 1953.

From January to April Mr Beggs of the Cambridge Observatories used the Cambridge pulse-counting photoelectric polarimeter on the Victoria Telescope to observe the polarization of the light of certain southern stars. During April,

May and June, ten nights of the time allotted to the Cape with the Radcliffe Reflector were placed at his disposal for similar observations of fainter stars.

Dr Koelbloed of the Astronomical Institute of the University of Amsterdam worked at the Cape from the end of April to the middle of June when he went north to the Radcliffe Observatory. He used the Victoria Telescope to observe a number of the brighter southern galactic clusters, obtaining 709 three-colour photoelectric observations of stars in NGC 3532, 6124 and 6475 and a number of photographs of NGC 3532, 3766, 4755, 6124, 6281 and 6405. 27 pairs of plates were obtained by or for Dr Koelbloed who has taken them back to Amsterdam for measurement. Some of these plates are intended for photometric measurement and some are to be used with existing plates of an earlier epoch to obtain proper motions.

Variable stars.—Mr R. P. de Kock continued the programme of observing long period variable stars which he began twenty-two years ago. Each star is observed as nearly as possible at five-day intervals and the results are forwarded monthly to the headquarters of the American Association of Variable Star Observers. During 1954, Mr de Kock made 5964 observations of 176 stars with the Six-inch Telescope. He also kept a special watch on T Orionis and on two "flare" stars 013418 UV Ceti and 203501 AE Aquarii. The photoelectric photometer attached to the Astrographic Refractor was used on 9 nights to make 60 observations of AL Velorum and BL Telescopii.

Occultations.—91 observations of 50 phenomena were made with various telescopes at the Observatory. 12 of these observations were made photoelectrically, the remainder visually.

Photoheliograph.—The Sun was photographed on 333 days, two photographs being taken on each day except five. 24 plates of the partial eclipse on Christmas Day were obtained though conditions were very poor and rain interfered with the observations. A special objective shutter was used and the time of the exposures automatically registered on a chronograph. All the photoheliograph plates have been sent to Herstmonceux for measurement.

Armagh Observatory

(*Director, Dr E. M. Lindsay*)

The programme on an Armagh–Harvard Atlas of the Southern Milky Way was commenced, using the ADH telescope. Exposure times are 75 minutes for red plates with filter and 60 minutes for blue plates on eighty-eight centres at galactic latitudes 0° and ±3° and between galactic longitudes 210° and 328°.

A series of blue ADH plates was taken on the Large and Small Magellanic Clouds to provide some fifteen to twenty further basic magnitude sequences with magnitude range 13–16·5. The Small Cloud programme was completed; the Large Cloud 60 per cent completed.

Observations of eclipsing binaries with the 60-inch Rockefeller telescope and attached photoelectric photometer were continued. RT Sculptoris, which had been observed in 1951–52, was reobserved through several minima. FU Arae was covered over all phases but two more runs are needed through primary minimum. Some further observations were obtained on GM Carinae.

Meteorological observations and reductions were carried out by Miss Sheelagh Grew.

Dr Öpik has continued his theoretical investigations. His main fields during the past year have been meteor statistics and theory, life-time and origin of the unstable small members of the solar system and the age of the Universe.

Contributions Nos. 10–13, Leaflets Nos. 20–24 and Harvard Reprint No. 379 have been distributed. Contributions Nos. 11–13 have been published : No. 11, " Interplanetary Gas " by E. J. Öpik (*Zeit. f. Astroph.*, **35**, 53, 1954); No. 12, " Disturbances in Dwarf Stars caused by Nuclear Reactions and Gas Diffusion " by E. J. Öpik (*Mem. in 8° Soc. Roy. Sc. Liège*, **14**, 187, 1953); No. 13 " The Chemical Composition of White Dwarf Stars " by E. J. Öpik (*Mem. in 8° Soc. Roy. Sc. Liège*, **14**, 131, 1953). Leaflets Nos. 23–27 have been published.

Papers in press or completed are : "The Distribution of the Stream Intensity of Meteors over the Celestial Sphere ", " The Masses of Meteors " and " Dust and Star Formation in Supernova Explosions " by E. J. Öpik (*Mem. in 8° Soc. Roy. Sc. Liège*); " Meteor Radiation, Ionization and Atomic Luminous Efficiency ", by E. J. Öpik (*Proc. Roy. Soc.*); " The Masses and Structure of Meteors ", Abstracts by E. J. Öpik (Manchester Symposium on the Physics of Meteors, Pergamon Press); "Emission Objects in the Small Magellanic Cloud showing the N_1, N_2 Nebular Lines " by E. M. Lindsay (*M.N.*); " The Photoelectric Light Curve of V499 Scorpii " by G. G. Cillié and E. M. Lindsay; " The Photoelectric Light Curve of RT Sculptoris " by G. G. Cillié and E. M. Lindsay. Dr Öpik has continued to edit *The Irish Astronomical Journal* published by the Irish Astronomical Society and to write the comments on recent progress in astronomical research.

Mr F. E. Kameny joined the staff for a year as from October 1. Negotiations regarding the immediate future of the Boyden Station of the Harvard Observatory were finally completed at a meeting held in Hamburg Observatory in August, Professor Brück representing both Armagh and Dunsink Observatories. A Haffner photometer has been ordered from the firm of Sartorius-Werke and delivery is expected about 1955 July. Visitors to the Observatory numbered approximately 2000. Dr Öpik attended the 6th Liège Symposium on " Solid Particles in Astronomical Objects ", a grant towards travelling expenses being made by the Royal Society. The Director was absent for the six months June–November on observational programmes in South Africa, acting at the same time as honorary Superintendent of the Boyden Station.

Cambridge Observatories

(Director, Professor R. O. Redman, F.R.S.)

New equipment.—The 17/24-in. Schmidt telescope has been brought into regular use. The only serious trouble encountered was a periodic error in the drive, of total range about 6″, which has now been rectified. The optical performance is very satisfactory. With a filter removing the ultra-violet a 30^m exposure on an Ilford Zenith plate gives measurable images of stars fainter than $18^m{\cdot}0$ pg.

The old Common 36-in. reflector has been dismantled and returned to the Science Museum, South Kensington. The dome has been cleared and the foundations for the new 36-in. reflector are ready. The new telescope has been assembled by Messrs Grubb, Parsons and delivery in Cambridge is expected early in 1955.

An extremely fine Babcock grating, of ruled area 20 × 13·7 cm, has been lent by the Mount Wilson and Palomar Observatories for use in a solar magnetograph of the Babcock type which is being built with the aid of a grant from the Department of Scientific and Industrial Research. This instrument, designed to give a record of the distribution of magnetic fields over the surface of the Sun, will be attached to the spectrograph in the solar research tunnel.

Solar research.—The chief solar work of the year was the observation of the total eclipse of 1954 June 30. A ground party consisting of Professor Redman, Dr and Mrs von Klüber and Dr Dewhirst, with Dr A. H. Jarrett of the St Andrews University Observatory, worked on the island Syd Koster, off the south-east coast of Sweden, where they shared a site with the London University Observatory group under Professor Allen. Although hindered by thin cloud most of the observational programme was carried through successfully.

Dr von Klüber and Dr Jarrett photographed the inner corona in the light of the green 5303 A line, through a Fabry–Perot interferometer, using a Hilger interference filter and a film specially prepared by Kodak Ltd. The eclipse took place near sunspot minimum, with the 5303 A line unusually weak, so that conditions for this work were most unfavourable. The interference fringes show rather low contrast, as might be expected, but are measurable both positionally and photometrically. Line widths have been derived at a number of points in the corona. This method, repeatedly tried without success by other observers during the past quarter of a century, has now been demonstrated to be perfectly practicable, and under favourable conditions is capable of measuring line widths, temperatures, and possibly line-of-sight velocities over the whole corona in a single photograph.

Dr Dewhirst obtained satisfactory photographs of the ultra-violet spectrum at two different levels of the lower chromosphere, using a quartz prism spectrograph. The spectrograms are calibrated photometrically to allow measurement of the chromospheric electron temperature by Zanstra's method. Professor Redman photographed the chromospheric spectrum over the range 3600–4200 A, at 1·1 A/mm, using a diffraction grating of excellent quality, lent by the Mount Wilson and Palomar Observatories, but obtained only the strongest lines, on account of light lost by cloud.

With the cooperation of the Royal Air Force, Dr Blackwell and Mr Hignell photographed the corona in excellent sky conditions, at an altitude of about 30 000 ft north of the Shetlands, through the open door of a special Lincoln bomber. They used a camera specially designed for freedom from false light, with 8 simple bloomed lenses of red glass. Some of the photographs were taken through polaroid, used nearly in contact with the plate. Measurement of the images is now in progress. An accurate light distribution should be obtainable to more than 40 radii from the Sun; beyond 15 radii the isophotal contours become strongly elongated along the ecliptic.

The eclipse work was carried out with the aid of a grant from the J.P.E.C. Acknowledgment should be made of the enthusiastic cooperation of the R.A.F. station at Upwood (Group Capt. R. A. C. Carter), and of much assistance received on Syd Koster from Mr Jan Högbom and Mr M. F. Ingham. The Swedish authorities were helpful in the prompt handling of equipment and Swedish residents treated the visiting astronomers with much kindness. The Cambridge party are specially indebted to Lektor B. Svenonius, Mr I. Holm and Mr E. Hansson.

Work on the photography of the chromospheric spectrum obtained at the 1952 eclipse has continued and a paper has been communicated to the Society by Professor Redman and Dr Suemoto, who have shown that the hydrogen line widths are consistent with a kinetic temperature in the range 6 000–10 000 deg. K, when self-absorption and Stark effects are taken into account. There is evidence for an increase with height of line-of-sight velocities, probably as a result of turbulence. Mr D. V. Thomas has used the CN bands near 3800 A to determine the excitation (rotational) temperature, also using the 1952 spectrograms. The results support a low temperature (near 6000 deg.) for the chromosphere. This work has been helped by the kind cooperation of the Dominion Astrophysical Observatory, Victoria, B.C., where the Cambridge microdensitometer tracings were reduced to intensity records with the automatic machine.

Mr B. E. J. Pagel has completed an investigation of centre-limb variations in the equivalent widths of nine infra-red Fraunhofer lines of Fe I in the neighbourhood of 15 500 A. The observational material consists of tracings taken with the McMath-Hulbert Observatory duplicate infra-red spectrometer attached to the Snow Telescope on Mount Wilson; the tracings were made available by courtesy of Dr R. R. McMath and Dr I. S. Bowen. The analysis of the results has been carried out on the EDSAC at the University Mathematical Laboratory, Cambridge. The measurements can be interpreted satisfactorily by a photospheric model differing comparatively little, except very near the surface, from models recently proposed by Aller and Pierce (1952), de Jager (1952), and Michard (1953).

Some improvements have been made by Mr Argue to the infra-red solar spectrometer, which is at present being used with a quartz prism, in an attempt to measure the infra-red spectra of prominences. Mr B. G. Tunmore has continued work on the polarization of light from prominences.

The investigation by Dr Blackwell and Dr Dewhirst of the problem of photographing the solar surface with high optical resolution, which was mentioned in last year's report, has been much interrupted by the eclipse work outlined above, but substantial progress has been made.

Stellar photometry.—The results of the photoelectric measurement by Mr Yates of pg and pv magnitudes of dwarf stars within 20 parsecs of the Sun have been communicated to the Society. The narrow-band photometry mentioned in last year's report has been suspended, on account of the dismantling of the Common reflector, but will be resumed when the new 36-in. reflector is in commission.

Mr Yates has made a preliminary examination of plates taken with the 17/24-in. Schmidt telescope, to assess their suitability for stellar photometry, using the Eichner photometer at the Dunsink Observatory, by kind permission of Professor H. A. Brück. Work has begun on the design of a measuring machine for plates from this telescope.

Mr D. W. Beggs has returned to Cambridge after spending nine months at the Cape and Radcliffe Observatories, where he carried out measurements of polarization of star light. Thanks are due to H.M. Astronomer at the Cape and to the Radcliffe Observer for the help and encouragement they have given to this work. The results are now being worked up.

Other investigations.—Partly as a convenient means of testing the performance of the 17/24-in. Schmidt telescope, an experimental programme of photography

of discrete radio sources has been undertaken using positions supplied by the Cavendish Laboratory's radio astronomy group. As far as the radio sources are concerned the results up till now have not been encouraging and it may prove that most of them cannot be profitably photographed with this telescope.

In cooperation with the radio astronomy group Dr Dewhirst has identified the ring of nebulosity IC 443 with an extended radio source. He is also assisting with examination of nearly 2000 sources, mainly of small diameter, the positions of which have been accurately measured by the Cavendish Laboratory team, with the aim of finding whether there are significant coincidences with known optical objects.

Dr P. B. Fellgett has continued the construction of his multi-channel infra-red spectrometer, which is now sufficiently advanced to allow the first laboratory tests of the whole instrument.

Dr Beer has nearly completed an analysis of all available data on spectroscopic binaries. He is commencing a study of the peculiar A star θ' Mic, using spectrograms kindly lent by the Radcliffe Observatory, Pretoria.

Optics.—Dr Linfoot and Dr Fellgett have made an investigation into the problem of assessment of optical images. An optical image can be described as the convolution of the object with a spread function, characteristic of the optical system and varying relatively slowly over the working field. Over a part of the field in which this spread function is approximately constant, the Fourier transform of the image is the product of the Fourier transforms of the object and of the spread function, and the Fourier components of the object reappear in the image multiplied by so-called transmission factors. These factors, first considered by Duffieux, are evaluated in terms of an iconal function which can be computed from the design data of the system. Two types of image assessment are studied. In the first, an image is assessed according to its similarity to the object as measured by the r.m.s. "distance" between the two intensity distributions which represent them, and this distance is expressed in terms of the iconal function through the transmission factors. In the second, the image is assessed according to the amount of information about the object (in Shannon's sense) which can be extracted from it by suitable interpretation processes.

Experimental work has been continued on the production of mirrors relatively free from thermal distortion, which would be useful for solar work. Vitreous enamel on a steel support is easy to work and has good thermal properties, but in the disks tried the optical surface was spoilt by clouds of microscopic bubbles in the enamel. Experiments are now being made with disks prepared by Aero Research Ltd, of thin glass bonded with plastic glue to a mild steel support. Chromium-plated steel is also being tried.

Observatory Club.—Twelve colloquia were held during the year. The speakers included Dr J. Houtgast, Mr G. M. Sisson and Dr P. A. Sweet.

Cavendish Laboratory

(*Director, Professor N. F. Mott, F.R.S.*)

1. *Solar.*—Regular observations have been maintained of the intensity of the solar radio emission on wave-lengths of 1·7, 3·7 and 7·9 m. A new series of observations with an interferometer of variable aperture and inclination has been made to determine, at a time of minimum solar activity, the distribution of

radio "brightness" across the solar disk on a wave-length of 60 cm. Previous observations near sunspot maximum (**1**) did not show the limb-brightening predicted theoretically; recent measurements at 21 cm (**2**) on the other hand showed marked limb-brightening at this wave-length at a time of low sunspot activity.

The new 60 cm observations (**3**) which were made in the period 1954 April–July showed well-defined limb-brightening in equatorial regions, and a smaller effect in polar regions. Unlike the theoretical curves (**4**), however, the maximum brightness did not occur at the limb, but at a considerably smaller radial distance of about $0{\cdot}6\ R_0$.

Advantage was taken of the eclipse of 1954 June 30 to check the distribution derived interferometrically, and excellent agreement between the predicted and observed eclipse curves was obtained.

Observations were made during the period 1954 June 6–28 of the occultation of the Crab Nebula by the solar corona. The observations which were again made at wave-lengths of 3·7 m and 7·9 m confirmed the results obtained in 1953 June.

2. *The Cambridge survey of radio stars.*—A survey of radio stars between declinations $-38°$ and $+83°$ using the large radio telescope (**6**) has now been completed (**7**). The survey, which was made on a wave-length of 3·7 m, enabled 1936 sources to be located and the positions of about 500 could be determined with an accuracy of $\pm 2'$ of arc in R.A. and $\pm 12'$ of arc in declination. Thirty of the sources were of large angular diameter (20′–120′ of arc), and the most intense of these were situated close to the galactic equator.

The remaining 1906 sources were of small angular diameter and, with the exception of a few of the most intense sources, their diameters were too small to be measured. About 100 of them appeared to be related to objects in the NGC and Index Catalogues, and an intense source was found close to the position of Kepler's Nova, 1604.

Apart from a remarkable concentration of intense sources near the anti-centre, the sources of small angular diameter appear to be distributed isotropically. An analysis of the number-intensity relationship shows, however, that the observations are not compatible with a homogeneous distribution of sources; there is an apparent increase in the spatial density, or absolute luminosity, with distance. The latter effect was also noted by Bolton, Stanley and Slee (**8**) in their survey of 104 sources.

It appears impossible to explain the present observations in terms of sources situated within the galaxy, or by irregular clustering of extra-galactic sources. It may also be shown, from arguments based on the integrated radiation from the sources, that the region within which the apparent density increases must have dimensions comparable with those of the optically observable Universe. It is therefore concluded that the majority of the radio stars must belong to an extremely rare class of extra-galactic object, and that the observed features are due to effects on a cosmical scale (**9**). This result has important consequences in distinguishing between different cosmological theories, and also offers an explanation for the difficulty of finding optical objects related to the majority of the sources; only a small fraction of the sources observed in the present survey would lie within reach of the 200-inch telescope.

3. *Observations of the Andromeda nebula.*—Observations have been made at a wave-length of 3·7 m to determine the distribution of radio brightness across the

Andromeda nebula (**10**). Interferometers of different resolving powers and having axes inclined in four different directions relative to the nebula were used. The results showed (*a*) that the radio emission extended to considerably greater radial distances in the plane of the nebula than would be expected from optical data, and (*b*) that the extent normal to the plane of the nebula showed an even greater discrepancy : the observations could be explained if about two-thirds of the total emission were due to a population of sources contained within a sphere having a minimum radius of 10 kpc.

The existence of a similar population in the galaxy would account for a large fraction of the intensity observed in polar directions, which was previously thought to be due to extra-galactic sources (**11**).

4. *The general radiation.*—Observations of the total radiation between declinations $-28°$ and $+82°$ have been made at a wave-length of 3·7 m using one of the elements of the large radio telescope (**12**). The observations have shown the presence of a distribution similar to that considered by Westerhout and Oort (**11**) as well as the more concentrated feature extending over $\pm 2°$ from the galactic equator (**13**); they have also confirmed the results suggested by the observations of the Andromeda nebula, that a large part of the radiation observed in polar directions is not extra-galactic in origin, but is due to a more or less spherical distribution about the centre of the galaxy, whose radius is of the order of 10 kpc (**14**).

A theoretical analysis has been made of the average emission per unit volume of extra-galactic space due to normal galaxies and to colliding galaxies; using the value derived, estimates have been made of the total intensity of extra-galactic radio emission according to different cosmological theories (**15**).

5. *The spectra of radio sources.*—Observations have been made to determine the " spectra " of a number of intense radio stars in the range 7·9 m to 60 cm and of the background radiation from 7·9 m to 1·7 m (**16**). These have involved the establishment of some accurate standards of noise power based on the thermal noise from a heated resistance.

6. *The scintillation of radio stars.*—Measurements made in conjunction with observers in Washington, the Gold Coast and Helsinki have shown that whilst the diurnal variation of the occurrence of scintillations is similar at all the observing stations, there is no evidence for any detailed correlation between the occurrence at widely separated sites. This result therefore favours the hypothesis that the ionospheric irregularities are due to some mechanism originating within the atmosphere. A comparison of the Cambridge observations over the period 1949–54 shows however a marked decrease with solar activity (**17**).

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University Observatory, Glasgow
(Director, Professor W. M. Smart)

Dr Tannahill has now completed his determination of the constants of the star streams, on Eddington's two-drift hypothesis, from the Boss proper motions. The results for the A-type stars—as described in the previous report—have now been communicated to the Society (*M.N.*, **114**, 593, 1954). An examination of the proper motions of the B-type stars has yielded the surprising result that these stars, previously considered as exhibiting only the solar motion, show drift-characteristics similar to those of later types. The constants of the streams (rather ill-determined owing to the paucity of the data) are not notably different from those obtained from other groups. In particular, the longitude of the vertex of star-streaming is 343°. Anomalous behaviour is noted in the Scorpio–Centaurus region. The results of this work have been communicated to the Society (*M.N.*, **114**, 460). Dr Tannahill is now investigating systematic differences between the Boss Catalogue and the Cape Zone Catalogues.

Mr M. W. Ovenden has completed his photometric study of the eclipsing binary GO Cygni, and the results have been communicated to the Society. The investigation has produced evidence that asymmetries in the light-curves of close eclipsing binaries between minima may be attributed to absorption by gaseous envelopes.

Dr A. E. Roy has held a Cormack Fellowship from the Royal Society of Edinburgh, Robert Cormack Bequest Committee, during the year. He and Mr Ovenden have shown that the frequency of occurrence of near-commensurability of mean motions among pairs of planets and satellites in the solar system is greater than in a chance distribution (*M.N.*, **114**, 232, 1954). In a paper which has been communicated to the Society, Dr Roy and Mr Ovenden relate these statistics to a special class of periodic orbits in the *n*-body problem, and give reasons for believing that near-commensurable configurations of pairs of satellites are relatively more stable than adjacent configurations.

Mr D. G. Ewart has completed the analysis of the proper motions in the Cape *Catalogue of 20 554 Faint Stars*. The results of the analysis have been communicated to the Society (*M.N.*, **114**, 467, 1954). Mr Ewart has also analysed the photographic proper motions of 16 538 stars in the Cape Photographic Zones $-30°$ to $-35°$ and $-35°$ to $-40°$, both on the two-drift and the ellipsoidal hypotheses. The principal features of the results are the low values obtained for the drift velocities and the solar motion. Correspondingly high values are found for the axis-ratio of the ellipsoid. Through the kind cooperation of Dr R. H. Stoy and Mr J. v. B. Lourens of the Royal Observatory, Cape of Good Hope, the material for the analysis was forwarded before the publication of the catalogues. Mr Ewart has also investigated the relationship between the two-drift and the ellipsoidal theories of the distribution of stellar linear velocities.

A relation is derived between the axis-ratio of the velocity ellipsoid and the relative velocity of the drifts, which, on being applied to the results of various analyses of proper motions, gives values of the axis-ratio in agreement with those derived from the same motions by analyses by the usual methods. The results of this investigation have been communicated to the Society.

University of London Observatory
(*Director, Professor C. W. Allen*)

Parallax.—The parallax observing programme will close shortly. During the year 36 parallax plates were taken and 2 stars have been measured. There are now 9 ready for measurement.

Star clusters.—Mr V. C. Reddish completed his observation of the colour magnitude arrays of clusters, adding NGC 1528 and 2682 to earlier lists. The cluster NGC 2682 was found to have an array intermediate between those of globular and open clusters.

Laboratory spectroscopy.—Spectra of a water vortex stabilized arc have been obtained by Mr E. W. Foster for the measurement of oscillator strengths in atomic oxygen. Mr Asaad's measurements of oscillator strengths in certain elements from the study of arc spectra of dilute copper alloys are making progress.

Solar eclipse of 1954 June 30.—An expedition was sent to Syd Koster, Sweden, in order to make photometric and spectroscopic measurements of the outer corona. A new occulting disk (or bar) method of photometry was tried for the first time. The eclipse was observed through thin cloud, but measurements are being made from the photographs obtained.

Use of instruments.—The Radcliffe 24/18-inch refractor has been used on 38 nights for observations of parallax, clusters, double stars, and minor planets. The Wilson 24-inch and smaller instruments have been used by students and visitors.

Theoretical work and analysis.—The Director has studied the mode of oscillation giving rise to the sunspot cycle. Dr P. A. Sweet has written papers on the structure of sunspots and field reversal in magnetic variable stars. He is investigating the structure of rotating stars and giving attention to the origin and isotropy of cosmic rays. Dr R. H. Garstang began an extensive series of computations on transition probabilities of forbidden lines arising from levels in the ground configuration of ionized atoms of the first long period. Attention is initially concentrated on [Fe III], [Fe V] and [Ni III]. Mr T. Kiang has investigated the zero-point of the period–luminosity relation for classical cepheids. He has also examined the colour excesses of the B stars in relation to the inner spiral arm of the Galaxy.

Publications.—The following communications have been published during the year :

No. 13, C. W. Allen, " The physical condition of the solar corona ", *Rep. Prog. Phys.*, **17**, 135, 1954.

No. 14, V. C. Reddish, " Stellar Evolution ", *The Observatory*, **74**, 68, 1954.

No. 16, R. H. Garstang, " Intermediate coupling line strengths ", *M.N.*, **114**, 118, 1954.

Staff and students.—Mrs J. M. U. Armstrong replaced Mrs F. B. Harland as confidential clerk in July; Mr R. V. Thornton replaced Mr J. R. Coy as technician in October; and Mr V. C. Reddish left the Observatory to take up a position as lecturer in Edinburgh in October.

Since October there have been one post-graduate student and eight undergraduate students taking either regular lecture courses or practical astronomy.

New building and equipment.—A concrete hut was erected to house two electric motor-generators which have been received on loan from the Admiralty. A Hilger recording photoelectric microphotometer has been purchased.

Visitors.—Mr P. J. Nind has paid frequent visits to the Observatory to assist with visitors and the measurement of parallax plates.

There were 355 afternoon and evening visitors during 1954.

Radar Research Establishment, Ministry of Supply, Malvern

The apparatus for observation of the 1420 Mc/s hydrogen line is nearing completion. A conversion equipment has also been constructed to enable the apparatus to operate at 327 Mc/s, at which frequency a weak deuterium line is predicted. The apparatus should attain a sensitivity of about 0·05 deg. K, which is achieved by means of several hours' integration. An attempt will first be made to detect the deuterium line from the galaxy, and subsequently to detect the hydrogen line in Andromeda.

The observations of the radio sources in Cygnus and Cassiopeia at the comparatively low frequency of 22·6 Mc/s (**1**) have indicated that the intensities continue to increase with decreasing frequency. By comparison with other measurements up to 160 Mc/s, the law for Cassiopeia appears to be that intensity is proportional to $(\text{frequency})^{-1\cdot2}$. The Cygnus source shows a less rapid increase at the lower frequencies, which may possibly be due to interstellar absorption.

The asymmetry in the solar distribution of flares with associated radio bursts has been analysed in relation to geomagnetic activity (**2**). The analysis indicates that, although the asymmetry is emphasized in the flare-active regions which cause high geomagnetic character figures, the asymmetry appears to be a general characteristic. The asymmetry may be attributed to absorption associated with the structure of the solar atmosphere, including corpuscular streams, in the vicinity of the active regions. Asymmetry in the distribution of visual flares also indicates optical absorption.

The solar eclipse of 1954 June 30 was observed at wave-lengths of 10 cm and 3 cm at Ledbury, near Malvern, where the magnitude of the optical eclipse was 0·71. The results obtained indicate that limb brightening occurred as expected, and a more detailed analysis is now proceeding to determine the distribution of radio brightness. In preparation for the eclipse a survey of previous eclipse observations was prepared (**3**).

Mr R. J. Lees organized an expedition to Sandefjord, Norway, to observe the eclipse at 8 mm wave-length in a region of totality. A site was chosen approximately 150 yards from the line of centrality. Although the sky was not clear, there was not sufficient cloud attenuation to introduce an appreciable error in the results. The observations have been subjected to correcting routines, such as

for the atmospheric attenuation due to oxygen and water vapour. A very crude preliminary analysis shows a marked increase of brightness round the periphery of the Sun. More precise analysis will be carried out shortly, on the parallel digital computer at R.R.E.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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Jodrell Bank Experimental Station, University of Manchester
(Director, Professor A. C. B. Lovell)

The radio telescope.—The constructional work on the radio telescope proceeded satisfactorily during 1954. At the time of the previous report the main foundation work was nearing completion. This was completed as anticipated by the end of 1953. Similarly the final details of the power house extension, installation of switchboards, etc. were also completed towards the end of 1953.

The main 350 ft diameter, 17 ft gauge, double railway track was laid in 1954 January and February. At that time discussions about the erection programme of the main steel superstructure were taking place. Many months' work was first necessary to erect the cranes. Although this programme began in February and March, the final pair of 15 ton, 120 ft. cranes, mounted on 120 ft. steel gabbards moving on their own independent railway tracks, were not ready for use until the end of July. Very rapid progress was then made with the main erection. The central pivot, which had been fixed in position during the summer according to programme, received the main 20 ton cross girder in early August. On this the erection of the diametral girder began in mid-August. The main diametral girder is complete, the chord girder is completed on one side, and the two main towers are erected to 140 ft. above ground level. Four driving bogies and four wind bogies have so far been delivered.

The construction of the control building commenced in the autumn of 1953 and is now well advanced. Final development of the control system has been made and the manufacture of the final console and racks is now proceeding.

In the last report it was anticipated that the main steel superstructure would be erected by the end of the summer of 1954. This hope has not been realized. The present programme is that the structure should be finished to tower level by the end of 1955 January, and the bowl fabricated during the spring and summer of 1955. Hence there are still grounds for belief that preliminary testing of the instrument may begin in the autumn of 1955.

Extra-galactic radio emissions.—The measurement of extra-galactic radiation with the 218 ft. paraboloid has been discontinued at 158·5 Mc/s and a completely new receiver has been constructed for use at about 90 Mc/s. It is hoped that by the use of this lower frequency it will prove possible to tilt the beam of the paraboloid further from the axis and thereby survey a greater area of the sky. The new electrically operated tilting mast of the 218 ft. paraboloid came into operation in the autumn of 1953. This has already been used extensively in the work with

the rotating-lobe interferometer described below and will also greatly facilitate the proposed programme on 90 Mc/s.

Galactic radio emissions.—An interferometer, operating at about 18 Mc/s, has been constructed in order to measure the distribution of intensity across the galactic plane. In order to avoid long-range interference and absorption in the ionosphere these measurements must be made during the summer. Since the instrument was not in full working order until the late summer the measurements have been postponed until next year.

All the available data on the discrete sources close to the galactic plane have been analysed; it has been shown that, on certain speculative assumptions, the only sources which are known to be in the Galaxy might be the remnants of supernovae (**1**).

Diameter of the radio stars.—The measurements of the distribution of intensity across the discrete source in Cygnus have been continued with the post-detector correlation interferometer at 125 Mc/s. Observations of the variation of the correlation coefficient have been extended to baselines of 5000 λ along the major axis of the source. Further work with this instrument has now been discontinued, and effort is being concentrated on developing an instrument which will measure both the relative amplitude and phase of the interference patterns at different baselines. A complete mathematical theory of the post-detector correlation interferometer has been published (**2**).

The rotating-lobe interferometer, which operates in conjunction with the 218 ft. paraboloid and a small mobile aerial, has been in operation at 158·5 Mc/s. The preliminary tests of this instrument show that the principle is sound and that it is possible to control at will the frequency of the interference pattern observed from a discrete source with a baseline of any length and direction (**3**). The technique promises to have a particularly valuable application to the observation of weak sources of small angular diameter. The first measurements carried out with this new instrument were concentrated on the intense sources close to the galactic plane which had been observed during a previous survey with the fixed paraboloid. It was found that a number of these sources have large angular diameters of the order of one or two degrees. One of these sources has been identified with a faint nebulosity in Auriga (**4**).

An attempt to observe the intense discrete sources in Cygnus and Cassiopeia by means of an interferometer operating at 12 Mc/s has, so far, proved unsuccessful, due to the reception of excessive interference. It is intended to improve the aerial system with the object of reducing the reception of interference at low angles of elevation.

Wind movements in the F region of the ionosphere.—The three receiving equipments used for measurements of drift movements in the F region by the radio-star fading method are at present being modified in preparation for routine observations during the International Geophysical Year (1957). New steerable arrays of four Yagis have been built and the baselines between the triangularly situated stations will be increased from 300 metres to 1000 metres; these alterations will permit observations to be taken more frequently and with greater accuracy. In the interim before the Geophysical Year it is hoped to investigate the seasonal and geomagnetic dependence of the times of " reversals " in the F region motion and to make a more comprehensive survey of movements in the auroral zone.

A new equipment has been put into operation to study the temporal variations of radio-star fading. This operates at 79 Mc/s and is connected to a broadside aerial array of six full-wave dipoles mounted on an equatorial axis which is so driven that the main beam of the aerial is continuously directed towards the Cassiopeia radio source. Half-hourly values of the fading amplitude and fading rate are being used for a detailed and long term investigation of the daily, seasonal, and annual variations of these phenomena and of their correlation with ionospheric storms and with geomagnetic variations.

Experiments with spaced receivers have also been carried out to investigate the shape and rate of change of the ionospheric irregularities which cause radio-star fading. The results so far obtained suggest that the irregularities are anisotropic; 3·5 km in the east–west direction (the direction of motion) and 8 km in the north–south direction. It is thought that the extension in the north–south direction may be due to diffusion of the ionization along the geomagnetic lines of force. The decay time of the individual irregularities is approximately 20 seconds; it is interesting to notice that if they are assumed to result from turbulence in the F region they would be predicted to have decay times of this order (**5**).

Hydrogen line.—The 1420 Mc/s hydrogen line receiver was put into operation in 1953 December and is in use with the 30 ft. aperture paraboloid which is now equipped with automatic tracking for sidereal motion.

A new method has been developed for the measurement of the distance of radio-stars from the absorption of the stars' continuous radiation by the interstellar gas clouds at the hydrogen line frequency. A comparison of the observed absorption with that expected for radiation traversing a spiral arm enables a source to be placed with respect to the spiral arms in the Galaxy. It has been found that the intense source in Cygnus is extragalactic and that the source in Cassiopeia lies between the two arms of the Galaxy (**6**). Both these estimates are consistent with the visual identification of the sources by Baade and Minkowski.

An investigation has been carried out of some absorbing regions observed at the hydrogen line frequency near to the galactic equator in Taurus, Auriga and Cygnus and an attempt has been made to correlate these with dark nebulae. Coincidence has been found between the radio absorbing regions and irregularities in the star counts of Pannekoek in these regions.

Aurorae.—Radio echoes from the aurorae have been obtained on only two occasions during 1954 ($19^h\,30^m$ U.T., August 7 and $18^h\,30^m$ U.T., September 20). Both these aurorae were of a few minutes' duration. They were detected on the NW aerial of the radiant equipment but were too weak for detection on the all-round looking equipment.

It has been found possible (**7**) to make an unambiguous interpretation of the geometry of reflection for the aurorae observed on the all-round looking equipment in 1953. This interpretation of the observations has been especially important in view of the current conflicting hypotheses concerning the geometry and mechanism of the radio reflections. It was concluded that the radio echoes were due to direct, non-specular reflection from an auroral arc extending more than 1000 km along a parallel of geomagnetic latitude. The reflection apparently occurred in a region of the arc of limited vertical extent at a height of about 125 km. The width of the reflecting regions normal to the arc was not more than 10–20 km. The observed line-of-sight velocities of intense reflecting

centres were interpreted as true motions along the arc with velocities of 1–2 km/sec.

During the operation of the continuous meteor survey equipment, 36 aurorae have been observed on the NW aerial prior to 1954 January. Some of the earlier observations have been published. The observations have been re-analysed (**8**) and are found to be consistent with the geometry of reflection deduced from the all-round looking observations. The most outstanding new feature to be found in this re-analysis is a systematic change in velocity of the reflecting regions from a mean of 600 m/sec E to W at $18^h\,00^m$ U.T. to 600 m/sec from W to E, at $06^h\,00^m$ U.T. The change in direction of motion at $21^h\,00^m$–$22^h\,00^m$ coincides with the minimum in the diurnal frequency of aurorae.

Meteor survey.—The continuous survey of meteor activity has been continued. Rates and radiants for all the major day and night-time streams have again been measured. The Giacobinid stream, which produced a strong shower on 1952 October 9, when the Earth was 6 months in front of the parent comet, and was therefore expected to appear again in 1953 when the Earth was 6 months behind the comet, produced no meteors on that occasion although a very careful watch was made on a number of equipments (**9**).

Meteor orbits.—A new system using three spaced receivers has been constructed and has been in operation throughout 1954. This measures the velocity and radiant position of individual meteors and thereby enables the orbits of single meteors to be determined. 200–300 orbits can be obtained from 24 hours' observation of sporadic meteors, with an accuracy of 3 per cent in velocity and 2° in radiant position. A programme of observations of sporadic meteors is in progress which will give the detailed distribution of orbits throughout the year. In addition observations of the major showers have been made. Arrangements are in hand for the mathematical analysis to be carried out on the Manchester University Digital Computer. From the first 400 sporadic meteors analysed one had a markedly hyperbolic orbit. It is believed that this is the first example of a meteor with an origin certainly beyond the solar system.

Meteor physics.—Measurements of atmospheric scale height and pressure in the altitude range 85–105 km using the meteor height finding equipment have been continued. The scale height measurements continue to be in good agreement with the rocket values and exhibit no diurnal or seasonal variation greater than about 0·5 km. Upper limits of about 20 and 10 per cent respectively have been obtained for the diurnal and seasonal variations in atmospheric pressure in the above altitude range. A study has also been made of the diffusion of ionized meteor trails in the upper atmosphere (**10**).

Measurements of height and echo-duration frequency distribution have been interpreted to give information concerning the mass distribution of the various major meteor streams.

Studies of the influence of the polarization of the incident radio wave on the character of the radio echoes have been continued and the phase changes in the initial part of the echoes have been measured. The results in both cases can, with some possible exceptions, be interpreted in terms of existing theories of the scattering of radio waves from a column of ionized gas.

Upper atmospheric winds.—Systematic wind measurements in the region 80–1000 km above the Earth have now been in progress for over a year. The

method depends upon radio echo observations of the drifts of ionized meteor trails under the influence of the high altitude winds. Measurements have been carried out for two periods of 24 hours each month, and the hour by hour variation in wind speed and direction has been studied. The wind system in the lower E region shows a number of regular features not observed at ground level (**11**). The most important of these is the semi-diurnal periodic wind. This component can be approximately represented by a vector of amplitude 10–30 m/sec rotating in a clockwise direction with a period of 12 hours. During most of the year the vector is directed towards the north at approximately $06^h\,00^m$ and $18^h\,00^m$, local time. Near the autumnal equinox, however, the phase of the rotation undergoes a remarkable variation, changing by almost 360° (12 hours) in approximately six weeks.

In addition to the 12 hour periodic wind, a small oscillatory component with a period of 24 hours has been resolved. This component has an amplitude of 5 m/sec and is directed towards the north at mid-day. Steady winds with magnitude of 10–20 m/sec are generally superimposed upon the periodic component. These prevailing winds are towards an easterly quadrant in summer and winter, and towards a westerly quadrant in spring and autumn.

Lunar echo work.—Observations of Moon echoes have been made at transit on about 80 days from 1953 September to 1954 September, using the horizontally polarized array described in the last report. The echoes show a rapid fluctuation characterized by a Rayleigh distribution of amplitude and a quasi-period of less than one second (**12**). This is attributed to the effects of libration, taking account of the monthly, diurnal and physical terms, and shows that the Moon reflects radio waves as though it were composed of many random scatterers. A more detailed study of the rapid fluctuations is planned in order to estimate the scattering law of the lunar surface as a function of the angle of incidence.

In addition to the rapid fluctuations, the mean echo amplitude averaged over several minutes shows a slow variation, which is slight during the night, but prominent during daylight. A subsidiary experiment using crossed dipole feeds at the focus of a 30 ft. paraboloid showed that at least the greater part of this slow fading is caused by a rotation of the plane of polarization of the received wave. This can be explained as a magneto-ionic effect, the angle of rotation being proportional to the total number of electrons contained in a column of unit cross-section along the line of sight. A new method is thus indicated for studying the ionosphere, particularly the F2 layer which makes the major contribution to the total electron content. In order to extend the study of these effects, the equipment is being modified to operate on three close-spaced frequencies, while a vertically polarized array is being erected as a complement to the present array.

Publications.—Number 3 of Volume 1 of the *Jodrell Bank Annals* has been published during the year. It contained papers by Z. Kopal ("A Study of the Roche Model"); J. G. Davies ("A Table for the Calculation of Meteor Velocities"); and a paper by Bullough (**13**). Oxford University Press have also published the book by A. C. B. Lovell on *Meteor Astronomy* in the International Series of Monographs on Physics (**14**). Other publications have included the semi-popular *Occasional Notes*, entitled "Radio Astronomy" by the Staff of the Experimental Station (**15**); further technical details of the new Radio Telescope (**16**) and accounts of the Symposium on Meteor Physics held at Jodrell Bank in July (**17**).

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University Observatory, Oxford
(Director, Professor H. H. Plaskett)

New solar telescope.—The telescope was declared open by the Vice-Chancellor at an informal ceremony on June 1. Later in the year a tender was received for the mechanical parts of the associated large spectroscope; work on these parts is now going forward steadily. In the meantime chromospheric spectra with a radial slit and low dispersion have been obtained by Mr R. O. Bishop with the new telescope to find the variation of Hα and He D_3 with solar latitude. This observational programme will be continued.

Determination of solar and laboratory wave-lengths.—As reported last year, Dr M. G. Adam found a systematic error in wave-lengths measured at 6490 A and 6570 A. The origin of this error has now been traced, and a new series of solar and laboratory spectra was completed during an exceptionally bad observing season. Dr Adam will shortly be communicating to the Society her results for these regions, as well as a general discussion of the observed red shift.

Motions in the solar photosphere.—Dr A. B. Hart (*M.N.*, **114**, 17) has found evidence for persistent motions at the solar equator. These have an amplitude of 0·2 km sec^{-1} and extend over several degrees of longitude. Her results have been incidentally confirmed in the course of an investigation on the motions associated with granulation (*M.N.*, **114**, 251). Apart from a significant correlation of velocity with surface brightness of granulation, there exists a perturbing velocity field which appears to be a fine structure to the large-scale motion discovered by Dr Hart. In a new solar rotation programme, on which good progress is being made, fresh evidence is being obtained on the extent and persistence of these large-scale motions.

Solar spectrum.—Dr I. W. Busbridge and Dr D. W. N. Stibbs (*M.N.*, **114**, 2) have investigated the effect of interlocking on multiplets with a common upper state. Mr R. J. Bray has communicated a paper to the Society on the apparatus function of the large solar prismatic spectroscope with which he is determining the profiles of solar resonance lines. Dr W. R. Hindmarsh, seconded from

Harwell for seven months, is investigating the profiles of some Mn lines, using a modified interferometric method suggested by Dr Adam, in an attempt to detect effects due to hyperfine structure. With the same technique Dr T. D. Kinman, the new Radcliffe Travelling Fellow, is trying to find an upper limit to the equivalent width of the deuterium line in the wing of Hα.

Stellar work.—Dr Stibbs, who returned to Canberra in August on the termination of his Radcliffe Travelling Fellowship, continued his work on the radial velocities and intrinsic colours of the Cepheid variables. The International Astronomical Union published during the year the second volume of the Potsdam–Oxford zones of the Astrographic Catalogue. Both volumes have now been distributed.

University Observatory, St Andrews
(*Director, Professor E. Finlay-Freundlich*)

Staff.—Miss B. Middlehurst has been appointed Lecturer in the University of St Andrews.

Dr Kurth is spending a second term of research work with a D.S.I.R. grant and has been here since October 1.

Scientific research

(*a*) The eclipse expedition to Öland (Sweden), where I intended to measure once more the light deflection, was unsuccessful due to unfavourable weather conditions. Mr T. Slebarski and Mr R. L. Waland took part in this expedition. A new expedition has been organized, when it is intended to repeat the experiment in Ceylon at the total eclipse on 1955 June 20.

(*b*) The expedition to Syd Koster, Sweden, carried out by Dr A. H. Jarrett in collaboration with Dr. H. v. Klüber (Cambridge), has for the first time succeeded in obtaining interferometric fringes in the light of the corona line at 5303 A; they intend to repeat the experiment at the coming eclipse and to extend it to the line at 6374 A. Publication of the results obtained in Sweden is forthcoming.

(*c*) Research on the nature of the observed red shifts in the spectra of celestial bodies is continuing.

(*d*) Mr A. MacAulay's work is proceeding successfully.

(*e*) An auroral station, under Dr Jarrett's supervision, has been constructed on the grounds adjoining the Observatory and has been equipped with an *f*/0·7 spectrograph intended for auroral and night sky research during the forthcoming International Geophysical Year.

(*f*) Miss Middlehurst spent the year on leave of absence in the U.S.A. and did research work on radial velocities, photoelectric photometry and on scattering effects in early-type stars.

(*g*) Dr Cisar began, in collaboration with the Department of Astronomy of the University of Manchester, a photographic investigation of regions in the galaxy giving radio emission. The observations with the 20-inch Schmidt–Cassegrain telescope use interference filters provided by the Department in Manchester.

(*h*) Mr Slebarski has made observations with the Schmidt–Cassegrain telescope for the exact determination of positions of very faint celestial objects.

(*i*) Dr Kurth has joined in the editing of the book on celestial mechanics under preparation and has completed a paper on the foundation of statistical mechanics.

(*j*) The work on the designing of the heavy mounting for the 37-inch Schmidt–Cassegrain telescope by Mr Abbott, under the direction of Mr W. Stewart of the Engineering Dept., Dundee, has made good progress.

(*k*) In the workshop satisfactory progress has been made in the design and construction of the lower half of the 37-inch Schmidt–Cassegrain telescope containing the primary and secondary mirrors.

The building to house the 37-inch telescope is practically completed; the construction of the dome is under preparation.

Publications.—A. H. Jarrett, "On interference filters for auroral work", *Q.J.R. Met. Soc.*, 1955; E. Finlay-Freundlich, "Uber Rotverschiebungen der Spektrallinien kosmischer Lichtquellen, *Forschungen und Fortschritte*, **28**, No. 12, 1954.

Norman Lockyer Observatory of the University College of the South West

(*Director, Mr D. L. Edwards*)

Weather during 1954 was exceptionally bad and night work limited, thereby slowing down progress, especially in the relative gradient programme, though the techniques involved have received special consideration. The sensitometer has been partially redesigned in order to increase its accuracy and extend its range, and probable errors of observation arising at various stages have been quantitatively determined. In particular, variations in emulsion thickness of the plates used have been found ranging up to ± 12 per cent, with consequent errors in observed densities which are not entirely eliminated by normal procedures. An empirical method of correction has been developed.

The spectrum of γ Cas has been kept under observation and has continued to show slight changes in hydrogen emission and in gradient. Mr F. M. Holborn has kindly supplied a long series of visual magnitude observations from 1937 onwards, and a similar series has come from Mr P. Moore. These observations are being analysed for the investigation of magnitude variations.

The results from observations of 7 galactic clusters have been published, but this work is now again in abeyance, owing to lack of staff.

The work on the twilight sky includes: interferometric analysis of *D*-line intensities with a Fabry etalon; direct photography of the Na arc bordering the Earth shadow, and of the emission pattern in an area of the sky approximately $120^\circ \times 150^\circ$; the effects of ozone and water-vapour absorption on the seasonal fluctuation of Na emission; temperature estimates from observations of the twilight decrement at 4600 and 5893 A; *D*-line emission and associated geomagnetic activity. A new photoelectric photometer with photomultiplier is being constructed for attachment to the Littrow spectrograph; this will be used to measure the intensity and polarization of the *D* lines in twilight and daylight spectra of the zenith sky.

Dunsink Observatory

(*Director, Professor H. A. Brück*)

Staff.—Dr M. J. Smyth, formerly Lecturer at Edinburgh University, has been appointed Chief Assistant as from September 1. Dr G. I. Thompson has been appointed Assistant in succession to Mr F. J. O'Connor who has left the observatory.

Equipment.—The mirrors for the new 28-inch Cassegrainian telescope have been delivered by Messrs Cox, Hargreaves & Thomson, Ltd., but problems of mounting and drive have yet to be settled before the instrument can take the place of the dismantled 15-inch reflector. The 28-inch telescope is to be used entirely for photoelectric work, and a suitable photometer of the photon-counting type is at present being constructed by Dr Smyth.

New quartz mirrors for the Cassegrainian solar telescope of 14, 10 and 7·5 inches in diameter have been delivered by Messrs Cox, Hargreaves & Thomson, Ltd. Their installation has provided an opportunity of improving the mountings of the optics and other parts of the solar equipment.

A Shortt clock consisting of a free pendulum and slave has been acquired and mounted in the basement of the observatory, the free pendulum in a chamber which is temperature controlled.

ADH Telescope.—The future operation of the ADH Schmidt Telescope which had become imperilled by the threatened withdrawal of Harvard College Observatory from the Boyden Station, has been secured through an agreement between six institutions concerning the operation of the Station after 1955 June 30. The agreement was arrived at during a meeting at Hamburg Observatory of representatives of the six cooperating observatories, namely Armagh, Bruxelles, Dunsink, Hamburg, Harvard and Stockholm.

Solar work.—Intensities in the continuous spectrum and equivalent widths of Fraunhofer lines have been determined by Dr Thompson in parts of the region between 3400 and 3800 A from second and third order spectrograms and using a direct intensity recording apparatus which he has constructed on the Utrecht model. Dr Thompson has also measured the instrumental profile of the spectroscope in the 1st, 2nd and 3rd orders of the grating using the Kr 4319 line and giving all-night exposures for the line wings. The results are being prepared for publication.

Solar eclipse expedition.—Several months have been taken up completely by preparations at Dunsink and on Öland, Sweden, for observation of the total solar eclipse of June 30. The main programme of the expedition was to be a repetition of the experiment carried out at Khartoum in 1952, of photographing the flash spectrum with a Fabry–Perot interferometer. A larger telescope and spectroscope was used and a five-layer etalon with a resolving power of 220000. A subsidiary experiment was to be concerned with measurements of the brightness and polarization in the outermost corona. Dr D. A. Jackson, Dr M. T. Brück and Professor H. A. Brück took part in the expedition. Observations were completely spoilt by cloud.

Stellar work.—The Eichner plate photometer has been used for measurement of certain plates of open star clusters taken with the ADH Telescope. These plates have shown the need for further observational material which is to be secured early in 1955.

Visitors.—Among visitors to the observatory from abroad have been Professor Heitler, Zürich; Professor O. Struve, Berkeley; Sir G. I. Taylor, Cambridge; and Mr G. G. Yates, Cambridge.

Dominion Observatory, Ottawa
(*Director, Dr C. S. Beals*)

Positional astronomy.—With the completion of a catalogue of stars, observed with the Ottawa meridian circle 1935–50, the back-log of computations has been brought well up to date. Meridian circle observations on photographic zenith tube stars in use or needed at Richmond, U.S.A., Greenwich, and at Ottawa, were completed, and the reductions are well advanced towards completion. Observations on a new programme comprising 3000 stars north of $-27^\circ\ 30'$, in the FK3 catalogue, and the FK3 supplemental list, were started in January and 4500 observations were taken during the year. Completion of the meridian circle computations was hastened by employing facilities of the University of Toronto Computing Centre for part of the work. They were also used for computing daily apparent places for the photographic zenith tube stars.

The photographic zenith tube was in operation on 150 nights, 175 clock corrections and latitude determinations being made. The probable error for a clock correction from one star is $\pm 0^s{\cdot}017 \cos\phi$. The Ottawa latitude values reached their lowest value $38''{\cdot}25$ in 1953 April, and seemed to be at a maximum near the end of the year.

The new measuring engine for scaling P.Z.T. plates, designed by M. M. Thomson and fabricated in the Observatory machine shop, was completed and has been in use for the past six months.

Time signals have been broadcast continuously over station CHU on 3330 kc/s, 7335 kc/s, and 14 670 kc/s. Two speaking clocks were received in August, and are being tested previous to being placed in use announcing the time each minute over CHU.

A ring crystal was received in July and installed on a pier in the clock vault by J. S. McClements of the Post Office Research Station, London, England. It is proving a valuable addition to the other four crystal clocks and has a much steadier rate. Corrections for variation of longitude have been applied since June. The original time-signal machines, controlled by the crystal clocks, transmit time signals over telephone lines to the Canadian National and Canadian Pacific Railways, and the master clocks in government buildings.

Plans for building a " Mirror Transit " mentioned in the last report are still being studied.

Stellar physics division.—Two expeditions were organized for the observation of the total solar eclipse of 1954 June 30. The first was located at Smoky Falls, Ontario, lat. 50° 04′ N, long. 82° 10′ W. It was planned to photograph the flash spectrum with a grating spectrograph giving 0·9 A/mm dispersion and also with two slitless spectrographs crossed with Fabry–Perot interferometers. This expedition was clouded out.

The second was a joint airborne expedition in which the National Research Council of Canada cooperated with the Dominion Observatory in carrying out the scientific part of the programme while the Royal Canadian Air Force

provided the aircraft and crew. Successful slit spectrograms of the corona and flash were photographed with two Hilger quartz spectrographs mounted in a North Star aircraft. To avoid clouds it was necessary to fly at the height of 27 500 ft and the observations were made at an approximate position lat. 57° 36′ N, long. 61° 00′ W. Work is now progressing on the photometric reduction of these records.

During the year the two Super-Schmidt meteor cameras and six smaller meteor cameras were in routine operation at the meteor observatories at Meanook and Newbrook, Alberta. In Ottawa, in cooperation with the National Research Council of Canada, the Delta Aquarid and Perseid meteor showers were observed by radio, photographic and visual methods. A total of 2762 photographic exposures was made on the meteor programmes at all stations and 1032 meteors were observed visually. In general the meteor observations were greatly handicapped in 1954 by unusually poor weather and a bright Moon at the maximum of some of the best showers.

A study of the New Quebec (Ungava) Crater profiles was made, using the results of an air-photographic survey of this feature completed by the Royal Canadian Air Force in 1953 August. This investigation lends support to the hypothesis of a meteoritic origin for this crater.

Progress was made in the theoretical study of explosion crater formation. A general hydrodynamical theory of impact and of shock waves was applied to this problem; and consideration was given to the nature of the ground motions following the impact of a large mass moving at speeds greater than 10 km/sec. A model, based on the simplifying assumption that the ground deforms elastically, gave surprisingly good agreement with controlled HE experiments and with known terrestrial meteor craters. This model is now being refined by allowing for the non-elastic response of the ground at pressures greater then 10^6 kg/cm^2.

Detailed studies of visual and radio meteor rates, of meteor magnitude distributions, and of the relation between the duration of meteor radio echoes and the absolute visual brightness of the meteor, were continued in collaboration with the National Research Council.

Observations of a bright detonating fireball of 1954 January 13 were collected and a study was made of the original records of the great meteoric procession of 1913 February 9.

Terrestrial magnetism.—Magnetic survey operations were carried out by ground parties in Eastern Canada between latitudes N 44° and N 53° and longitudes W 67° and W 85°, in Western Canada between latitudes N 49° and N 55° and longitudes W 112° and W 129°, and in the Arctic Islands between latitudes N 71° and N 79° and longitudes W 75° and W 125°. Measurements of declination, inclination and force were made at 88 points comprising 21 repeat and 67 new stations. The Dominion Observatory three-component airborne magnetometer was flown about 30 000 miles, entailing 145 flying hours. Flights were made over the Arctic Islands and a fairly detailed coverage was obtained over the Atlantic Ocean to a distance of 300 miles from the eastern coasts of Labrador and Newfoundland. Two traverses were made across the North Atlantic, one along a great circle course between Gander, Newfoundland, and London, England, and the other from London to Goose Bay, Labrador, by way of Iceland. Magnetic profiles were obtained between Sydney, Nova Scotia, and Bermuda from which place a triangular flight was made extending about

800 miles to the east. Continuous records of declination, horizontal and vertical force were maintained on all flights.

The compilation and construction of isomagnetic maps of Canada for the epoch 1955·0 were completed. Isogonic and isoporic lines were drawn and magnetic data supplied for 1684 marine and air navigation charts and topographical map sheets.

The four magnetic observatories situated at Agincourt, Ontario, at Meanook, Alberta, and at Baker Lake and Resolute Bay, Northwest Territories, continued normal operations. A study directed towards determining the normal position and lateral movements of the auroral zone was commenced, based on the magnetograms from the four Canadian magnetic observatories.

Gravity.—In 1954 the Dominion Observatory carried out two major gravity investigations, one in Rocky Mountain Trench area of Southern British Columbia and the other in the Grenville province of the Precambrian Shield in Central Quebec. A total of 1250 regional stations was established using four gravimeters and employing both automobile and aircraft for transportation. This total includes the establishment of about 200 gravimeter base stations which are well connected to the primary gravimeter network of Canada.

In addition special emphasis was given to the problem of accurately determining the calibration factors of the gravimeters by comparisons with pendulum determinations. Measurements were made at the Cambridge pendulum stations established in 1953 between Lethbridge and Whitehorse in Yukon Territory, and at Mendenhall pendulum stations in Winnipeg, Churchill and Resolute Bay. Connections were also made between the National Gravity bases in Ottawa and Washington. Calibration factors accurate to 3 parts in 10 000 were obtained and it was gratifying to find that the Cambridge and Mendenhall pendulums gave calibrations that do not differ significantly.

The pendulum apparatus employed since 1902 by the Dominion Observatory is of the Mendenhall type, employing bronze von Sterneck pendulums. No stations have been observed with this apparatus since 1948, but it is of interest that progress is being made on its reconstruction and improvement. The new arrangement will provide for temperature control of the vacuum case, and will permit two pendulums to be swung at one time, in anti-phase. Timing will be by means of a crystal chronometer. It is expected that the apparatus will be ready for trial measurements next year.

Seismology.—The network of thirteen seismograph stations maintained by the Dominion Observatory has been continued without change. Assistance is being given to Brebeuf College, Montreal, where a seismograph station is being installed. This station will work in close cooperation with the government network.

The 12-channel radio-linked field seismograph announced last year has been completed, and was used during the summer to study a large circular feature in the vicinity of Lake Manicouagan.

The programme for studying the direction of faulting in earthquakes was continued. Information on about thirty additional earthquakes was collected and the analysis has been partly completed. A beginning has been made at summarizing the conclusions of the fault-plane project. It is already clear that transcurrent faulting is of greater importance in tectono-physical processes than is normally realized, and consistent patterns of faulting are beginning to appear in certain areas.

David Dunlap Observatory, University of Toronto
(Director, Professor J. F. Heard)

Radial velocities.—The major programme involving 1050 stars of type Go and later in Yale Zone $+25°$ to $+30°$ has been completed as regards radial velocity determinations. These stars have also been classified on the MKK system and a programme to measure their photographic magnitudes is well advanced. It is proposed to publish all these data together.

Measurement of the velocities of 36 high-velocity stars observed here has been completed by Dr Nancy Roman of the Yerkes Observatory. Observations of 56 suspected members of the cluster about α Persei have been completed, but not the measurements. Further progress has been made on several other radial velocity programmes initiated some years ago.

New radial velocity programmes undertaken during the year include (*a*) 55 stars in the galactic polar cap which are listed in Hins' General Catalogue of Positions and Proper Motions and which are brighter than photographic magnitude 10·1, and (*b*) 102 distant OB stars brighter than photographic magnitude 10·6.

Heard has obtained observations for spectrographic orbits of the eclipsing variables V566 Oph, V805 Aql and V548 Cyg. Miss Northcott has completed an orbit for the double-lined binary HD 200391.

Spectrographic.—Heard has continued observation of 53 Be stars for spectral variations. Hossack has continued a study of the strengthening of the hydrogen lines in the spectra of G- and K-type spectroscopic binaries.

Oke of this observatory and J. L. Greenstein of Mount Wilson and Palomar Observatories have made a study of the rotational velocities of A-, F-, and G-type giant stars, using high-dispersion spectrograms from Mount Wilson. Results were compatible with the idea of these stars having evolved from main-sequence A-type stars.

Photometric.—Mrs Hogg has been studying the light changes of various non-RR Lyrae variables in a number of clusters, particularly NGC 6273, 6712 and 6838, from series of plates taken with the 19-inch reflector over periods of several consecutive months.

MacRae has been supervising the determination of the photographic magnitudes of the 1050 stars of the radial velocity programme. A series of Schmidt films taken at the Hamburg Observatory are being measured at the Warner and Swasey Observatory on an iris diaphragm photometer. Photoelectric observations of magnitude and colour of 149 of these stars have been made here for the calibration of the photographic measures.

Stellar luminosities.—Spectrograms of dispersion 33 A/mm have been taken of about 200 F-, G-, and K-type stars having good parallaxes. Oke is making luminosity and spectral-type classifications of these stars, using micro-photometer tracings, with a view to calibrating the luminosity classifications to absolute magnitude with the highest possible accuracy.

Solar eclipse.—An Observatory party set up equipment at Mattice, Ont., in the path of the total solar eclipse of 1954 June 30, to photograph the flash spectrum in the far red region and to study the polarization of the red and blue light of the corona. Clouds interfered and no results were obtained.

Instruments.—Oke and MacRae have designed a new photoelectric stellar spectrophotometer which is now in the course of construction. The optical system is entirely reflecting, the dispersion being produced by a reflection grating.

Provision is made to do band photometry with band widths ranging from 2 to 150 angstroms and also to scan the whole spectrum.

Staff.—Miss Ruth J. Northcott was promoted to the rank of Assistant Professor.

Publications.—Since the last report, *Comm. D.D.O.* Nos. 35 and 36 were issued.

Dominion Astrophysical Observatory, Victoria
(*Dr R. M. Petrie, Dominion Astrophysicist*)

Staff.—Miss J. K. McDonald returned to the Observatory from the Computation Centre, University of Toronto, at the middle of the year, and G. J. Odgers returned at the same time from the University of California. Mr E. K. Lee joined the staff as assistant on January 11, and Mrs R. W. Edmonds resigned her position of assistant on September 30. Mr W. R. H. White joined the staff in seismology on November 15.

The following held temporary summer appointments: Dr A. H. Joy, Mount Wilson and Palomar Observatories; Professor J. B. Warren, University of British Columbia; Mr J. A. Galt, University of Toronto; Mr J. L. Climenhaga, Victoria College; Mr L. V. Wallace, University of Western Ontario; Mr J. N. Merner, University of British Columbia; Mr J. D. Francis, Victoria College.

Spectroscopy.—Work on the Victoria series of spectrograms taken near the time of the 1951 eclipse of the Zeta Aurigae-like binary, 31 Cygni, has continued. One study, by Miss A. B. Underhill, has traced the growth and decay in the chromospheric spectrum, immediately before and after total eclipse, of the four Fe I lines, λλ 3920, 3923, 3927, and 3930 (*Contr. Dom. Ap. O.*, No. 37). Another by A. McKellar, L. H. Aller, G. J. Odgers and E. H. Richardson, is a detailed study of the behaviour of the chromospheric lines of Ca II. It contains data on intensities and radial velocities and includes material from the Ann Arbor series of plates. The interpretation of the results more firmly establishes the concept of the chromosphere of the giant K-type star as consisting to a great extent of discrete moving masses of gas.

An intensive observational programme on the β Cephei star HD 199140 has been carried out by G. J. Odgers, the aim being to obtain high time-resolution. The cycle has been observed on eight nights with exposure times ranging from 2^m to 6^m, using the new ultra-violet spectrograph. The Hα region was photographed on three nights and a relatively high-dispersion spectrograph (18 A/mm at 4500 A) was employed on five nights of good seeing for the region 4300–4700 A. Light curves in four colours were obtained on one night with the photoelectric photometer.

Relative spectral gradients for ten carbon stars ranging in spectral type from early R to late N were measured spectrophotometrically over the region λ4800 to λ3900 by A. McKellar and E. H. Richardson. There was thus obtained a quantitative estimate of the drastic drop in intensity in the violet spectral region for certain late N-type stars. A comparison of the stellar absorption profile with those obtained in the laboratory (including a C_2 emission continuum of Phillips and Brewer at Berkeley and certain absorption continua of Norrish, Porter and Thrush at Cambridge) suggests that the C_3 molecule may contribute strongly to the opacity in the violet for the late N-type stars (*Contr. Dom. Ap. O.*, No. 39).

The spectra of several cool carbon stars and also those of other spectral types, for comparison, have been photographed, using Kodak IZ (2) emulsion in the region λ9000–λ11000, by A. McKellar. The dispersion used was 133 A/mm at λ10000. Over fifty absorption features were measured in the spectra of the carbon stars between λ9600 and λ11000; most of these absorptions must await the use of higher dispersion to be identified. The outstanding features are the four heads of the 0,0 band of the red CN system between λ10870 and λ11000. The work is published in *P.A.S.P.*, **66**, No. 392, 1954 December and as *Contr. Dom. Ap. O.*, No. 41.

Numerous spectrophotometric studies have been carried out by K. O. Wright. In collaboration with Professor S. A. Mitchell a number of eclipse flash spectra have been analysed with the microphotometer. The intensities of many iron and ionized titanium lines have been measured and excitation temperatures will be obtained.

The curves of growth constructed by Wright, using solar *f*-values, from the spectra of the high-luminosity stars α Persei and ϵ Aurigae, have been revised, making use of Crosswhite's recent laboratory measures of intensities of high-excitation lines. The revision confirms the previously discovered fact that the " turbulent velocity " is greater for the lines of lower excitation potential.

As part of a programme requested by Commission 36a of the International Astronomical Union, K. O. Wright and E. K. Lee are carrying out line intensity measures, with high dispersion, on the spectra of 15 Vulpeculae (A5), σ Bootis (F0), λ Serpentis (G0), and μ Herculis (G5). These measures will be compared with values derived at Pasadena and elsewhere and will form a system for general comparison and standardization.

The spectrum of the free NH_2 radical has recently been produced in absorption by Herzberg and Ramsay. In view of the presence of NH_3 in the atmosphere of Jupiter and the possibility of its photodissociation by sunlight into NH_2, spectrograms of Jupiter were obtained by A. McKellar with fairly high dispersion (4·7 A/mm). A careful comparison of the spectra of Jupiter with those of the sky failed to show any differences near λ5975 and λ6300, regions containing the strongest NH_2 lines. It is concluded that the NH_2 concentration in Jupiter's atmosphere is too low to be detected with the resolving power used.

High-dispersion grating spectrograms (dispersion 3·5 A/mm) of the ultra-violet region as far as about λ3100 have been obtained for a number of early-type stars by A. McKellar and E. H. Richardson. The aim was to examine this region for possible new interstellar absorption lines. While no new lines have yet been found, the Na I pair at λ3302 appear in nearly all the spectra, and the $\lambda\lambda$3384 and 3242 lines of Ti II, reported in 1936 by Dunham and Adams as occurring in the spectra of several stars, have been noted in the spectrum of P Cygni.

Miss A. B. Underhill has continued studying the spectra of O stars. Observations of hydrogen line absorption are accumulating for an attempt at calibrating the luminosities. Spectra covering the region 3050–6700 A have been measured for wave-lengths and identifications and these will be supplemented with intensity measures. The C III line λ5696 has been found to appear in emission in the spectra of several late O-type supergiants, indicating possibly that the Of stars, in whose spectra this line is bright, are of high luminosity.

The spectrum of the star HD 50820, in the region $\lambda\lambda$3900–6700, has been studied by Miss Underhill, using high dispersion. The composite nature has

been confirmed but it appears that the spectra are about B3e, dwarf, and giant K1, increasing the spectral difference given heretofore.

R. M. Petrie and B. N. Moyls have continued testing the spectroscopic calibration of the luminosities of the B stars. It appears that existing proper motions are not yet of sufficient precision to give reliable mean parallaxes except for the nearest of these stars. Solutions by the galactic rotation criterion, using both stellar and interstellar radial velocities, have confirmed the spectroscopic absolute magnitudes. Using the Victoria spectroscopic calibration, Petrie has found a firm period–luminosity relation to exist among the β-Cephei stars.

During the year preparations were made to observe the solar eclipse of June 30. A high-dispersion grating spectrograph was designed and constructed for observations of the flash spectrum. The Observatory's party proceeded to Hansen, Ontario, but observations were prevented by overcast skies.

Theoretical.—Miss J. K. McDonald completed studies of model atmosphere computations for spectral types about B3. Tables of the Kourganoff exponential integral functions were constructed and are to be published as an aid to those studying stellar atmosphere, and scattering, problems. A discussion of the significance of model atmosphere computations is being prepared.

Miss A. B. Underhill has computed the total absorption of λ4542, He II, for a model atmosphere corresponding to O9 and an assumed H/He ratio equal to 24 : 1. The resultant equivalent width, 0·46 A, confirms her previous estimate that the relative abundance of hydrogen to helium in early-type stellar atmospheres lies between 20 : 1 and 25 : 1.

Stellar motions.—The observing on the extensive programme of B stars, carried on by J. A. Pearce and R. M. Petrie, is nearing completion with about 150 spectrograms yet to be obtained. At the same time several hundred spectrograms have been measured for radial velocity.

The North Galactic Pole programme is likewise well advanced, it being expected that observations will be completed this season. Radial velocities have been measured on about one-third of the plates and absolute magnitude estimates are proceeding.

Spectroscopic binaries.—Orbital elements have been obtained by J. A. Pearce for the two-spectra A-type system HD 23642, a member of the Pleiades cluster. K. O. Wright and R. E. Pugh have determined orbital elements for the F-type binaries HD 8634 and HD 9021. Radial velocities of κ Draconis have been measured, from new material, by Miss A. B. Underhill. She concludes that the star is not a binary. Studies of the eclipsing systems 31 Cygni, HD 190967 and S Equulei are continuing.

Photometry.—The photoelectric photometer has been partly rebuilt and improved and P. E. Argyle is now beginning programme work and special studies with it. Colours and magnitudes of stars on the B programme are being measured as well as stars in selected galactic clusters. During the year some 80 B stars have been measured and light curves have been obtained for UX Ursae Majoris and HD 199140. In addition, Argyle has constructed a device for the photoelectric scanning of visual binaries and has measured Δm in some 30 systems.

Seismology.—The Western Canada network has been operated continuously. Improved pick-up and recording devices have been installed. The locating of local earthquakes continues; this year some 200 have been recorded, none of them being sufficiently strong to have caused damage.

Travel-time curves for local seismic waves have been constructed following the completion of the depth-charge experiments. Local crustal depths appear to be normal, averaging about 33 km with $V_p = 6{\cdot}2$ km/sec.

Seismological recordings continue to be made in the coal-mining areas of south-eastern British Columbia and south-western Alberta. The work is intended to clarify the nature of dangerous outbursts in the mines, and is undertaken in collaboration with the Bureau of Mines.

Instrumentation.—The development of the new stellar spectrograph has continued with the completion of a quartz ultra-violet instrument. This instrument gives stellar spectra to the limit of atmospheric transmission with a linear dispersion of 40 A/mm at λ 3400. Fused quartz prisms for the comparison arc have been substituted for the original glass prisms. A Bausch and Lomb stigmatic, 1·5 metre, concave grating spectrograph has been added to the equipment. This instrument will be useful in obtaining spectra in the laboratory and the optical parts can be used in the stellar spectrograph.

A photoelectric exposure meter has been designed by Professor J. B. Warren and is being constructed in the shop. This device, operated by light removed below the slit, will give a positive signal when the correct exposure has been given, thus eliminating uncertainties due to guiding, weather, and stellar magnitudes.

A new 10-inch precision lathe has been acquired, and a start has been made towards fitting out an electronics workshop.

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Union Observatory, Johannesburg

(*Director, Dr W. H. van den Bos, Union Astronomer*)

The 26½-inch refractor has been used on 153 nights with the interferometer by Dr Finsen, for the measurement of known double stars and a survey for new ones, and on 48 nights with the micrometer by Dr van den Bos and Mr Churms. During the close approach of Mars in June and July Dr Finsen, assisted by Messrs Seligmann and Churms, obtained about 25 000 exposures of the planet and some of Saturn on colour film on 36 nights.

Visual and photographic observations of Mars were also obtained with the 9-inch refractor on 49 nights by amateur astronomers, members of the Transvaal branch of the Astronomical Society of South Africa, who also made observations of Saturn, variable stars, etc. with the instrument on 61 nights and rendered valuable assistance on visiting evenings and in many other ways.

With the 9-inch and 6-inch refractors 151 occultations have been observed by Messrs Bruwer, Churms and amateur astronomers.

With the Franklin Adams telescope the following plates were obtained by Messrs Bruwer and Churms:

Minor Planets	154 plates
Comets	33 plates
Miscellaneous	5 plates
Total	192 plates

In addition, 2 plates for minor planets and 9 for comets were obtained by Mr Bruwer with the Leiden southern station's Rockefeller telescope by kind permission of the Leiden Observer and 8 plates by Mr Churms with the 6-inch photovisual refractor.

Early in August the Franklin Adams telescope was moved to the Observatory Annexe at Hartbeestpoort, where it will have the benefit of a dark night sky.

Counts of sunspots were made on 308 days.

The Time Service is operated by Messrs Hers and Seligmann. During the year 1178 visitors were admitted on 35 nights.

Dr Muller was the Leiden Observer throughout the year and Mr van Woerden of the Leiden Observatory worked at the Union Observatory from April to October.

Astronomers Beggs, Burdecki, Cousins, Evans, Koelbloed, Martins, Paulo, H. and E. Smith, Stoy, Thackeray and Velghe visited the Observatory.

Radcliffe Observatory, Pretoria

(*Director, Dr A. D. Thackeray, Radcliffe Observer*)

Equipment.—While the 2-prism Cassegrain spectrograph continues to be the most intensively used auxiliary apparatus, a contract has been signed by the Trustees with Messrs Cox, Hargreaves and Thomson for a Coudé spectrograph utilizing a 6 × 8-inch Bausch and Lomb plane grating. The two dense prisms in the Newtonian spectrograph have been replaced by a plane grating so that low-dispersion spectra extending well into the ultra-violet can now be obtained.

The calibration spectrograph has been put into satisfactory service through a complete reorganization; among other changes a rotating sector replaces the wedge in front of the slit.

New equipment acquired during the year has been mostly photoelectric. A double dekatron pulse-counter, constructed in the workshops of the Cambridge Observatories, was used by D. W. Beggs during the year, and on his departure was purchased from the Cambridge Observatories. Further progress with the Cassegrain photometer has been possible by using an E.M.I. photomultiplier.

The Observatory is much indebted to the Electronics Section of the S.A. Council for Scientific and Industrial Research for assistance in improving the performance of the microphotometer and in the development of a photoelectric integrator.

The declination clamping system of the 74-inch reflector has been subjected to a thorough overhaul; certain modifications have been introduced with marked improvement in its performance.

Buildings.—A small cottage has been built in the grounds for housing Cape observers and their wives during their short-term visits to the Observatory. Additional rooms have also been built on to the Observer's and Chief Assistant's houses.

Observations. (*a*) *Radial velocities.*—A paper giving velocities of 148 southern stars, type O to B5, not hitherto observed, and of 38 other B stars with previously known velocities, was communicated to the Society and will appear in *Memoirs R.A.S.* Observation of 100 Bo–B2 stars with $m_0 - M \geqslant 11$ has been continued and this programme is expected to be finished in 1955; measurement and reduction of the plates is in progress.

The Radcliffe observations of southern B stars is being reinforced by a programme initiated by the Leiden observers, using the Radcliffe reflector, for deriving velocities of high luminosity stars discovered at the Tonantzintla Observatory.

A spectroscopic orbit of the double-lined binary HD 77464 has been published by the Society. Further observations of other binaries discovered at the Observatory have been made. The variable velocity star HD 224113 has been observed.

Observations of 24 northern B stars observed for overlap with the Dominion Astrophysical and Lick Observatories are essentially complete.

Southern Me variables are being observed for velocity.

Further observations of individual stars in 47 Tucanae have been made and measurement of velocities has begun.

(*b*) *Stellar spectroscopy.*—A note on the strengthening of Si 3905 in K-type dwarfs has been submitted to the Society. The same plates show Ca II *H* and *K* emission to be a common phenomenon in dwarfs of type K2 and later.

22 spectra of Nova Sgr 1954 (Haro–Herraro) were obtained between July 7 and August 20. Measurement and discussion of these spectra are complete. Further changes in RR Tel have been observed, [Fe V] appearing in 1954.

A number of bright members of the Magellanic Clouds have been established through radial velocity measures. HD 33579, the brightest, is of α Cygni type and is being studied in some detail. Further spectra of S Dor (29 A/mm and 49 A/mm at Hγ) have been obtained; a feature of special interest is the recent emergence of [Fe II] emission in this spectrum.

The eclipsing variables BL Tel, AR Pav, AL Vel and GG Car are being studied. AR Pav is of special interest in showing a nebular spectrum at all times, while developing Ti O absorption during minimum and supergiant F absorption near times of eclipse.

The peculiar stars AM Cen, GP Ori, UY Cen have been studied in regard to the ultra-violet absorption in carbon stars. This work was reported to the 1954 Liège Colloquium.

In an investigation of exciting stars within diffuse nebulae the star HD 156738, within NGC 6334, has been shown to be a heavily reddened O-type star; the HD type (G5) probably depended solely on colour. This result suggests the need for reclassification of 10th mag. stars in obscured regions. Bok's heavily reddened star HDE 316332 has been classified as B3 I.

A number of Me variables with large range have been observed for the study of emission lines. *o* Ceti has again been observed near minimum.

A new "symbiotic" star has been discovered.

(*c*) *Nebular spectroscopy.*—Observations of the nebular wisps in 30 Doradus have been continued. A long exposure on M8 (86 A/mm at $H\gamma$) has been measured for emission lines.

(*d*) *Direct photography.*—A comparison of Selected Areas 68 and 94 has led to a further revision of the distance of the Magellanic Clouds, the magnitudes in S.A. 94 previously used being apparently $0^m{\cdot}5$ too bright at $18^m{\cdot}0$.

Observations of NGC 1466 in the Large Cloud have been completed and the total number of variables (all short period) in this cluster has been increased to 37. Further studies of other clusters in the Clouds are in progress. Fields in the Small Cloud are being searched for signs of extragalactic nebulae.

A number of southern diffuse nebulae are being studied in a combined programme of direct photography and spectroscopy. A filter-emulsion combination specially designed to isolate green [O III] radiation is proving useful in locating regions of relatively high temperature. Infra-red photographs have been taken of some heavily obscured areas. NGC 6380 has been shown to be a heavily reddened globular cluster, well resolved on a red photograph.

The discovery of an interesting variable on the sharp edge of the largest "globule" near IC 2944 was reported to the 1954 Liège Colloquium.

Dr Koelbloed, of the Amsterdam Institute, used the Radcliffe reflector for (1) photometry of various planetary nebulae, (2) photometry of 30 Doradus, (3) a search for planetary nebulae in the Magellanic Clouds.

The Leiden observers photographed ω Cen for the purpose of studying variable stars.

Photographs of 47 Tuc have been secured with a view to setting up a colour–magnitude diagram based on a photoelectric sequence.

Four photographs of the asteroid Icarus were secured at an unfavourable opposition, the positions being measured at the Cape Observatory.

(*e*) *Photoelectric photometry.*—The Cassegrain photometer has been applied to the following problems in 3-colour photometry: integrated magnitudes of globular clusters, reduction of magnitudes to the Cape E-region system, sequence stars in 47 Tuc, high-luminosity stars in the Magellanic Clouds (established spectroscopically), some Cape Zone (faint) stars of type B (with a view to selecting unreddened stars for radial velocity work), the eclipsing variable RT Scl.

D. W. Beggs, of the Cambridge Observatories, used a polarimeter and pulse-counter on measures of polarization of southern stars.

General.—As in previous years, one-third of the observing time has been allocated to Cape observers. For details of this work, the report of H.M. Astronomer at the Cape should be consulted.

In a season of only moderate quality the telescope was used on 285 nights. The telescope was out of action for 7 nights in November for the overhaul of the declination clamp, and for two further nights on the occasions of the usual 6-monthly resilvering of the primary mirror.

Visitors.—The following visiting astronomers have used the telescope: from the Cape Observatory, D. W. Beggs (Cambridge), A. W. J. Cousins, J. H. Driver, D. S. Evans, J. D. Fernie (Cape Town University), J. v. B. Lourens, A. Morrisby, W. Rasmussen; from the Leiden Observatory, A. Muller, H. van Woerden; from the Washburn Observatory, T. E. Houck; from the Amsterdam Institute, D. Koelbloed. In addition it has been a pleasure to welcome the following visitors during the year; Professor R. W. Ditchburn, Sir Geoffrey and Lady Faber, Cyril Jackson, Dr and Mrs E. C. Slipher, Henry and Elske Smith, Dr and Mrs R. Stoneley, Dr R. H. Stoy and Dr W. H. van den Bos.

Owing to a sharp increase in public demand the number of visitors admitted on public nights has been increased. It is estimated that nearly 1000 visitors were able to view celestial objects through the 74-inch reflector during the year. These included 75 delegates to the Conference of the newly formed S.A. Institute of Physics.

Nizamiah Observatory, Hyderabad
(*Director, Dr Akbar Ali*)

Astrographic Equatorial.—The 8-inch photovisual object glass of the astrographic telescope, after refiguring and repolishing by Messrs Cox, Hargreaves and Thomson, Ltd., England, arrived at Madras in November and is expected here shortly after the necessary customs formalities.

37 plates were taken mostly in the ecliptic regions for minor planet and cometary work with the 5-inch Ross Astrocamera.

Work on the coordination of the results of the survey of photographic doubles in the Hyderabad Astrographic zones $-17°$ to $-23°$ is in progress.

Grubb Equatorial.—25 micrometrical observations of the minor planets Pallas, Juno and Ceres and a few physical observations of the comet Abell (1953g) were obtained.

22 occultations of stars by the Moon were observed and reduced. The results will be communicated to the Nautical Almanac Office for incorporation in the annual discussion.

Spectrohelioscope.—The Sun was observed on 135 days during the year for two hours on average per day. No flare was observed during the year. Dark filaments with 6 shifts towards violet and 3 towards red were observed. 8 prominences with 3 shifts towards violet and 5 towards red were also noted. The data of the solar observations have been sent for incorporation in the *Quarterly Bulletin on Solar Activity* (Zürich).

Publications.—The following have been sent for publication. (1) " A photoelectric study of early-type supergiants around h and χ Persei." (2) " Magnitudes and colours of some members of the Perseus Cluster." (3) " A catalogue of 1192 photographic double stars in the Hyderabad Astrographic zones $+36°$ to $+39°$."

Equipment.—The stellar photometer, whose metallic parts were constructed last year, has since been completed. The electronic components consist of a GEC.GL 918 photocell, a direct current amplifier of Kron type and a model B Avometer as indicating instrument. I am grateful to Mr Gajanand of the State Rural Broadcasting Department for constructing the amplifier and for his valuable cooperation in various other matters and to Dr Vainu Bappu for his assistance in its construction.

A 5-inch Dallmeyer lens was purchased locally and a camera has been constructed to fit it.

I am thankful to Nawab Himayat Yar Jung and to Nawab Ahmad Yar Jung of Khurshid Jahi Paigah for having kindly presented to the Observatory two 4½-inch telescopes, two chronometers and several telescopic accessories. Perhaps it may not be generally known that the Nizamiah Observatory owes its origin to the generosity of the late Nawab Zafar Jung, grandfather of the above donors, who presented to the Hyderabad Government in 1907 the 15-inch Grubb and the 8-inch photovisual telescopes along with other astronomical equipment for founding the Observatory.

With a view to modernizing the present equipment of the Observatory proposals for additional equipment have been submitted to the University for approval and sanction.

The two domes of the 15-inch and 8-inch telescope houses are leaking considerably. Proposals for covering the domes with masonite have also been sent to the University for sanction of necessary funds.

Miscellaneous.—The third meeting of the Standing Advisory Board of the Government of India for Astronomy was held at the Observatory on 1954 January 7 and 8, under the chairmanship of Dr S. C. Roy, Director General of Observatories.

Dr Vainu Bappu, who was working from 1954 January 1 as Senior Research Fellow of the National Institute of Sciences of India, under the supervision of the Director, was appointed Chief Astronomer of the Government Astronomical Observatory, Banaras, by the U.P. Government. He left for Banaras in October. During his sojourn he completed the papers on the photoelectric studies of the Perseus clusters.

Lectures in practical Astronomy were given to the graduate classes of the Osmania University.

The seismological work of the Observatory continued as usual.

The Director was on privilege leave for four months in the beginning of the year.

Kodaikanal Observatory, Kodaikanal

(Director, Dr A. K. Das)

General.—Matters relating to the establishment of a Central Stellar Observatory for India were discussed at the third meeting of the Standing Advisory Board for Astronomy and Astrophysics in India which was held at Hyderabad in 1954 January. The Director visited Udaipur, Ujjain and Aurangabad areas to prospect for possible sites for the proposed Observatory.

The requirements under the second five-year plan in respect of scientific equipment and machinery for the continuation or expansion of the schemes

relating to Astronomy and Geophysics already included in the first five-year plan and in connection with further new schemes were submitted to Government.

Satisfactory progress has been made regarding the acquisition of the polarizing monochromator, 8-inch coronagraph and the large solar telescope and spectrograph.

International cooperation.—This Observatory will participate in the intensive programme of observations relating to Solar Physics, Geomagnetism, Atmospheric Ozone, Ionosphere and Cosmic Rays during the International Geophysical Year, 1957–1958.

This Observatory participated in the photographic programme of the Mars Committee for international cooperation in the study of Mars during the 1954 opposition. Details of the photographs of Mars taken here from 1954 June to September were supplied to the Mars Committee, Lowell Observatory, Arizona, U.S.A.

Exchange of spectroheliograms with foreign observatories was continued. 253 *K*-disk spectroheliograms for the period 1953 October to 1954 September were sent to the Director, The Observatories, Cambridge University. 6 photoheliograms together with the relevant zero plates for certain specified dates in 1953–1954 were sent to the Astronomer Royal, Royal Greenwich Observatory, on request. For the period 1953 July–December, 35 H-alpha disk and 42 *K*-disk spectroheliograms were received from Meudon Observatory, France and 66 H-alpha disk and 71 *K*-prominence spectroheliograms from the Mount Wilson Observatory, U.S.A.

Quarterly statements relating to solar flares were sent as in previous years to Dr L. d'Azambuja of the Meudon Observatory and to Mr H. W. Newton of the Royal Greenwich Observatory.

The practice of broadcasting URSIGRAMMES relating to solar and geomagnetic activity and of issuing warnings for expected ionospheric and geomagnetic disturbances was continued.

The practice of supplying to the Chief, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado, U.S.A. the monthly median values of F2 layer critical frequency and the maximum usable frequency for 3000 km transmission was continued. Monthly median values of all other ionospheric parameters were supplied to him quarterly.

Eclipse expedition.—An expedition to observe the solar total eclipse of 1954 June 30 was organized and a party of three went to Phalodi in Rajasthan. The programme of observations was :

1. *Ionospheric observations.*—Continuous short-wave signal strength recordings for about 10 days to examine the influence of the eclipse on short-wave transmission conditions.

2. *Magnetic observations.*—Registration of the horizontal component of the Earth's magnetic field using an Askania field balance.

3. Atmospheric noise measurements from 540 kc/s to 29·5 Mc/s.

4. Photography of the solar corona with a 6-foot camera and a coelostat.

Due to poor sky conditions the optical part of the programme was not fully successful. The other observations were successfully made.

Routine observations.—Photoheliograms were taken on 299 days and visual observations of the Sun were made on 289 days as against 296 and 295 days respectively in 1953. H-alpha disk, calcium disk and calcium prominence

spectroheliograms were taken on 278, 264 and 251 days as compared to 285, 273 and 254 respectively in the previous year. Observations with the spectrohelioscope were made on 285 days.

The average definition of the Sun's image on a scale in which 1 is the worst and 5 the best was 3·1—same as in the past year. There were 17 days on which the definition was 4 or more.

Sunspot activity.—There was very little sunspot activity during the year. There were 243 spot-free days out of a total of 299 days compared to 142 spot-free days in 1953. The yearly mean latitude of all the observed spot-groups in the northern and southern hemispheres was 24°·8 and 20°·2 respectively as against 9°·0 and 8°·4 for the previous year. Details of sunspot observations are given in the following table :

Month		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
No. of new spot-groups	N	0	1	1	0	2	0	1	1	0	2	3	2	13
	S	0	0	3	2	0	0	0	2	0	0	2	1	10
Total		0	1	4	2	2	0	1	3	0	2	5	3	23
Mean daily no. of spot-groups		0	0·44	0·46	0·11	0·06	0	0·18	0·48	0	0·22	0·65	0·50	0·22
Kodaikanal relative sun-spot number		0	0·4	7·9	1·2	0·8	0	2·1	6·9	0	2·4	8·0	6·2	3·3

Solar flares.—2 solar flares were recorded during the year, both of intensity 1.

Radio astronomy.—Recording of solar noise at 100 Mc/s was continued and a 200 Mc/s radio telescope was under construction. Steps were taken for the acquisition of a 10-cm receiver from Australia.

Geomagnetic observations.—Continuous photographic recording of *H*, *V* and *D* with Watson and La Cour magnetographs and visible recording of the horizontal force with an Askania magnetic field balance were continued. A quick-run recorder for use with the Askania magnetic field balance was acquired during the year. Absolute measurements of *H* and *D* were made once a week with a Kew magnetometer and observations of inclination on 5 days in the week with an Earth inductor. A set of QHM and BMZ instruments was received towards the end of the year and put into regular use for absolute measurements.

During the year 7 magnetic storms with ranges in *H* between 130 and 170 were recorded. One of them was probably of the sudden commencement type.

Ionospheric observations.—Regular ionospheric observations during daylight hours with the automatic ionosphere recorder were continued.

Cosmic ray observations.—Systematic recording of cosmic ray intensity with the Kolhörster apparatus was not possible due to shortage of staff.

Seismology.—The Milne–Shaw seismograph (E–W component) recorded 96 earthquakes.

Meteorology.—Meteorological observations with all the visual and self-recording instruments were carried out as usual.

Library.—115 books and 1317 periodicals were added to the library.

Research work.—Under the Research Training Scheme sponsored by the Government of India, Ministry of Education, one Senior and two Junior research scholars were working in this observatory. The Senior Scholar was released from the scheme in 1954 August.

The following problems in astrophysics and geophysics were investigated or were under investigation during the year :

1. Experimental study of solar line contours by means of a direct-recording photoelectric photometer and by photographic photometry.
2. Variation of continuous absorption in the near ultra-violet solar spectrum.
3. Study of the spectrum of sunspots.
4. Study of ionospheric and geomagnetic effects during the total eclipse of the Sun of 1954 June 30.
5. Study of solar–weather relationships.
6. Study of ionospheric changes associated with M-type magnetic storms.
7. Disturbance daily variation of the magnetic field at Kodaikanal.

Publications.—The following notes and papers were either published or sent for publication :

(1) " Recurrence Tendency of Geomagnetic Activity during the current sunspot minimum ", *Special Geomag. number of Indian J. of Met. and Geophys.*
(2) " Solar Radiation in the far ultra-violet and some related geophysical phenomena ", *Special Geomag. number of Indian J. of Met. and Geophys.*
(3) " Equivalent widths of lines in sunspot spectra ", *Ap. J.*
(4) " Solar Influence on Barometric Pressure ", *Indian J. of Met. and Geophys.*
(5) Reports to the Society on (i) The work of the Kodaikanal Observatory and (ii) The prominence activity for the year 1953 for publication in the *M.N.*
(6) Annual Report of the Kodaikanal Observatory for the year 1953.
(7), (8) and (9) Kodaikanal Observatory Bulletin Nos. 139, 140 and 141 for the second half of 1952 and first and second halves of 1953 giving summary of the results of solar and magnetic observations.
(10) Quarterly synopsis of results of solar, magnetic and ionospheric observations, *Indian J. of Met. and Geophys.*

Commonwealth Observatory, Mount Stromlo

(*Director, Professor R. v. d. R. Woolley, Commonwealth Astronomer*)

The year 1954 has seen further progress in the Observatory's equipment programme. The dome of the 74-inch telescope arrived from England in June, and by the end of the year erection of the fabric of this dome was practically complete. It is expected to conduct tests on the 74-inch telescope towards the end of the first half of 1955. The 50-inch telescope (the former Melbourne 48-inch) has been equipped with motorized motions in declination and, partly, in right ascension. The primary mirror being spherical, it is necessary to use a special secondary mirror. This mirror has been successfully figured in the Observatory's optical shop, and the telescope has passed its preliminary tests very satisfactorily.

Progress has also been made with the dome for the Yale–Columbia Station. This is in the final stages of erection. The building for the Uppsala station is also complete but still lacks a dome. It is anticipated that this dome will be completed early in 1955.

During the early part of the year a transit building was put up, by the Observatory workshop, for an expedition from Munich Observatory financed by the *Deutsche Forschungsgemeinschaft*. This expedition consists of Drs Schmeidler and Heintz. They brought with them a vertical circle from

Munich and are conducting fundamental observations of declination. Work commenced late in May, and a satisfactory number of observations has been secured.

During the year observations were secured with the 30-inch and 20-inch reflectors and other instruments, of which details are given in the Annual Report of the Observatory. During the year Dr de Vaucouleurs left the Department of Astronomy of the Australian National University to take charge of the Yale Columbia Station, and Dr D. W. N. Stibbs returned from Oxford to rejoin the Observatory staff.

Riverview College Observatory, Riverview, N.S.W.

(*Director, T. N. Burke-Gaffney, S.J.*)

During the year 540 plates were taken for the variable star programme and a number of occultations were observed. Reprints 6 and 7 were distributed. Work was begun in preparing the next number of *Riverview College Observatory Publications* (which will begin a new volume); it is hoped that it will be issued in the course of the coming year.

Through the courtesy of Mr Charles Elphinstone, Acting Surveyor-General of New South Wales, Mr Anderson, of the Lands Department, determined the height above mean sea level, measuring to the base of the 7-inch refractor. This was in fulfilment of a promise made some years ago to complete the survey made in 1937, when the latitude and longitude of the Observatory were determined by the same Department. Until this year no one could be spared from the Department to complete the survey. The height determined was 26 metres.

The customary provision of astronomical and geophysical information to interested parties, public and private, was carried out. In particular, queries from insurance companies and other business firms, arising out of the Earth tremor in Adelaide early in the year, were numerous. The Observatory had the satisfaction, also, of being able to allay incipient public alarm at a suggestion that this tremor was "triggered" by the hydrogen bomb released at Bikini on the same day, by showing that the tremor preceded the bomb by a considerable interval.

The Observatory was honoured by a visit, early in the year, of Professor Otto Struve, President of the I.A.U. Several other visitors were received at various times during the year, and the monthly Visitors' Nights were especially well attended, much interest having been stimulated by the close approach of Mars to the Earth; it is feared, however, that much of this interest was ephemeral.

Sydney Observatory

(*Director, Harley Wood, Government Astronomer*)

The work on the Astrographic Catalogue has been continued, and Volume 35 is at present in the hands of the printer. Several more volumes are ready for publication. Volumes 4 and 5 of the Melbourne Catalogue, the manuscript of which was completed at Sydney, are now being published under the direction of Dr J. Baillaud in Paris. The work on Volume 6 is going forward and it should be completed in the first half of 1955.

The programme of observations of occultations predicted in the *Nautical Almanac* has been continued. The results for 1953 have been published and those for 1954 are reduced.

The work on observations of minor planets which culminate south of the equator has continued. An apparatus has been fitted to the telescope to assist in guiding the camera on minor planets.

We have been observing double stars by photography with the standard astrograph and it seems that satisfactory results will be obtainable. A series of measurements of double stars on the photographic plates taken for the Astrographic Catalogue Zones $-52°$ to $-58°$ has been published.

The civil and educational work of the Observatory has continued as in previous years and from April to June a series of lectures on Astronomy was given under the auspices of the Department of Tutorial Classes, Sydney University.

Dr Otto Struve, President of the International Astronomical Union, visited the Observatory in January.

Radiophysics Laboratory, Sydney

(*Director, Dr E. G. Bowen*)

The radio astronomy part of the Laboratory's programme, which is directed by Dr J. L. Pawsey, includes observations of solar and cosmic radio waves and theoretical studies.

The largest project is the study of the continuous component of cosmic radio waves with the " Mills Cross " type of radiometer. The 1500-foot, 85 Mc/s model described last year has been in operation since 1954 July and is working satisfactorily. It has an effective circular beam of diameter $\frac{2}{3}°$. It will be used for a survey of the sky south of declination about 10°, but in its preliminary testing period has been applied to the study of a number of interesting objects. These include external galaxies, emission nebulae and known discrete sources. An interesting case is that of the Clouds of Magellan over which 85 Mc/s brightness contours have been derived. In the case of the Large Cloud, these contours show a marked similarity to the 1420 Mc/s line emission contours, showing, for this case, an association between neutral interstellar hydrogen and the sources of the continuous emission. Such results emphasize the value of observations yielding an actual contour diagram rather than merely the positions and intensities of discrete sources. The interpretation of surveys of this kind calls for other high-resolution surveys at various frequencies, and a 20 Mc/s " Cross " of only slightly less resolving power is under construction.

Turning to the hydrogen line radiation, a new branch of the subject has been opened up by the discovery of line absorption reported by observers in Jodrell Bank and Washington. Similar observations of the absorption of the emission from " radio stars " by the interstellar hydrogen between us and the radio star were made in this Laboratory. Such observations give information not only on the relative positions of hydrogen and " radio star " but give also direct measures of optical depth leading to firm estimates of hydrogen temperature.

Of the solar observations the most striking result was the derivation of the 20-centimetre brightness distribution over the quiet Sun using a pair of high resolution (3 minutes of arc) Christiansen interferometers disposed at right angles.

The distribution shows marked departure from circular symmetry, limb-brightening being very marked in the equatorial regions and absent towards the poles. This observation nicely complements observations on longer wave-lengths obtained in Cambridge.

Observations of the scintillation of radio stars in Australia have previously given results differing from those in England. Recent observations of the Cygnus source, using a spectrum-type receiver working over the range 40–70 Mc/s, have confirmed the previous difference in diurnal behaviour: scintillations are not restricted to night-time in Australia. They have also shown that a considerable proportion of the intense scintillations must be due to focusing effects of lens-like irregularities in the ionosphere. These irregularities are considerably elongated like sea waves. A consequence of the elongation is that "wind" or "drift" observations using the conventional spaced receiver technique give false results for the component parallel to the ridges. The observations differ from the English not only geographically but in angle of elevation, being near the zenith in England and about 15° in Australia, and it is not known how these factors influence the phenomenon.

Brief notes are given below on some further investigations and others are indicated by the titles in the list of published papers.

1. *Cosmic radio waves*

(*a*) *Atomic line emission.*—In addition to the absorption measurements described above, observations are in progress of the 1420 Mc/s hydrogen emission from the southern Milky Way. This will complement the observations by Oort and his colleagues of the parts visible from Holland.

An attempt to observe the corresponding line of deuterium at 327 Mc/s from a number of places in the Milky Way gave negative results. A brightness temperature of 1 or 2 deg. K, i.e. about one per cent of that of hydrogen, would have been detected.

(*b*) *The continuous emission.*—In addition to the 85 and 20 Mc/s surveys noted above, a 600 Mc/s survey using a 36-foot parabola is well advanced and a small sample section of the Milky Way including the galactic centre has been surveyed at 400 Mc/s with a fixed 80-foot parabola. The latter survey focused attention on a discrete source which may well be the nucleus of the galaxy. Attempts to observe linear polarization from the galaxy have given negative results.

Measurements of the brightness distribution over a few discrete sources in Australia and England have shown them to have sizes ranging from minutes of arc to degrees. Simple interferometer observations of effective size in one direction are being made of a score or so of the brighter sources as a step towards the study of the statistics of angular size distribution.

2. *Solar radio waves*

(*a*) *Decimetre wave-length high-resolution observations.*—In addition to the quiet Sun results noted above, the 20-centimetre Christiansen interferometer observations taken over several years have provided a great deal of information about the "slowly varying" bright areas which are the common form of disturbance at this wave-length. They were found to have angular extents of a few minutes of arc and to be very closely associated with hydrogen and calcium plages. Detailed features are still being studied. A restricted series of observations with a resolution of 8 minutes of arc was made at 60 centimetres.

(*b*) *Dynamic spectra of metre-wave-length bursts.*—Owing to the inactivity of the Sun few observations were taken. The equipment is being remodelled with the object of observing simultaneously spectrum, position, and polarization. The method employed is to sweep the frequency over a substantial range while receiving on a pair of identical aerials connected to the receiver by unequal lengths of feeder. An interference pattern is then superposed on the spectrum. If the two aerials are parallel this pattern gives the source position; if perpendicular, the polarization.

(*c*) *Routine observations.*—Regular observations of intensity were taken on frequencies of 62, 98, 200, 600, 1200, 3000 and 9400 Mc/s and the results submitted to the *Quarterly Bulletin on Solar Activity*. The radio section of this bulletin is edited by S. F. Smerd of this Laboratory.

3. *The ionosphere*

The results of scintillation observations were described above.

4. *Theoretical*

The dynamics of ionized gases subject to electric, magnetic and mechanical fields of force, and oscillations in gaseous plasmas have been studied. On the practical side an investigation has been made of the distortion in a measured brightness distribution produced by the smoothing effect of the aerial beam and of possible methods for compensation.

5. *Publications during* 1954.

Bolton, J. G., Westfold, K. C., Stanley, G. J. and Slee, O.B., " Galactic radiation at radio frequencies. VII. Discrete sources with large angular widths ", *Aust. J. Phys.*, **7**, 96, 1954.

Bolton, J. G., Stanley, G. J. and Slee, O.B., " Galactic radiation at radio frequencies. VIII. Discrete sources at 100 Mc/s between declinations $+50°$ and $-50°$ ", *Aust. J. Phys.*, **7**, 110, 1954.

Bracewell, R.N., " Meteors and rain ", *The Observatory*, **73**, 249, 1954.

Bracewell, R. N., " Using cosmic radio waves to study solar flares ", *The Observatory*, **74**, 155, 1954.

Bracewell, R. N. and Roberts, J. A., " Aerial smoothing in radio astronomy ", *Aust. J. Phys.*, **7**, 615, 1954.

Davies, R. D., " An analysis of bursts of solar radio emission and their association with solar and terrestrial phenomena ", *M.N.*, **114**, 74, 1954.

Higgins, C. S. and Shain, C. A., " Observations of cosmic noise at 9·15 Mc/s ", *Aust. J. Phys.*, **7**, 460, 1954.

Kerr, F. J., Hindman, J. V. and Robinson, B. J., " Observations of the 21 cm line from the Magellanic Clouds ", *Aust. J. Phys.*, **7**, 297, 1954.

McGee, R. X. and Bolton, J. G., " Probable observation of the galactic nucleus at 400 Mc/s ", *Nature, Lond.*, **173**, 985, 1954.

Mills, B. Y., " Abnormal galaxies as radio sources ", *The Observatory*, **74**, 248, 1954.

Piddington, J. H., " Generation of radio noise by cosmic sources ", *Nature, Lond.*, **173**, 482, 1954.

Piddington, J. H., " Model solar chromospheres ", *Astrophys. J.*, **119**, 531, 1954.

Roberts, J. A., " Radio astronomy ", *Research*, **7**, 388, 1954.

Shain, C. A., " A comparison of the intensities of cosmic noise observed at 18·3 Mc/s and at 100 Mc/s ", *Aust. J. Phys.*, **7**, 150, 1954.

Shain, C. A. and Higgins, C. S., " Observations of the general background and discrete sources of 18·3 Mc/s cosmic noise ", *Aust. J. Phys.*, **7**, 130, 1954.

Shain, C. A. and Mitra, A. P., " Effects of solar flares on the absorption of 18·3 Mc/s cosmic noise ", *J. Atmos. Terr. Phys.*, **5**, 316, 1954.

Wild, J. P., Murray, J. D. and Rowe, W. C., " Harmonics in the spectra of solar radio disturbances ", *Aust. J. Phys.*, **7**, 439, 1954.

Wild, J. P., Roberts, J. A. and Murray, J. D., " Radio evidence of the ejection of very fast particles from the sun ", *Nature, Lond.*, **173**, 532, 1954.

Perth Observatory

(Director, Mr H. S. Spigl, Government Astronomer)

Arrangements were made to recondition buildings, grounds, and certain of the instruments, and a portion of this work was completed. During the coming winter period the astrograph and 12½-inch reflector will be overhauled.

The Western Australian standard time service has been maintained, the usual shipping, hourly, and other time signals distributed.

The Milne–Shaw horizontal seismograph record is complete, and was distributed to 55 cooperating stations. Preliminary data of movements within 5000 km of Perth were cabled to the United States Coast and Geodetic Survey through the American Consul. Seismological instruments for a cooperative programme with the Lamont Observatory, University of Columbia, were installed in 1954 February, and the records despatched monthly to Lamont Observatory for use in certain seismological enquiries.

Over 1500 visitors attended the evening sessions during the year, conducted on an average of two evenings per week with the exception of the winter months June, July, and August. A number of scientists attending the Pan Indian Ocean Conference visited the Observatory.

The Astronomical Society of Western Australia continues to avail itself of Observatory facilities for field nights, section meetings, and Council meetings.

The results of 36 occultations observed were sent to H.M. Nautical Almanac Office for incorporation in the full discussion. Tide tables for Port Hedland and the north-west coast, and appropriate astronomical data were completed for printing. A large number of tables of astronomical phenomena were distributed for various places throughout the State, and information furnished for the press, legal and general enquiries.

Geophysical Observatory, Christchurch, N.Z.

(Superintendent, Dr J. W. Beagley)

The Christchurch ionospheric recording station has now been established at Godley Head and installation of the reserve J28 automatic ionosonde at Rarotonga, Cook Islands is proceeding. This replaces the manual ionosonde which was operated there previously and should increase the reliability of data from this station. Continuous recordings of the ionosphere at Christchurch, Rarotonga and Campbell Islands have been maintained throughout the year.

A satisfactory method of analysing virtual height records to obtain true heights of the layers was evolved. This type of analysis can be used to include the effect of the Earth's magnetic field and is being utilized in an investigation of disturbance conditions in the ionosphere. Research into the lunar variation of the E region is proceeding and the development of a fixed-frequency ionosonde for fade-out investigations has been advanced. An analysis of geomagnetic sudden commencement amplitudes at Amberley, Apia and a number of American Coast and Geodetic Survey magnetic stations has been carried out and investigation into forces causing these transient changes of the Earth's magnetic field commenced.

The cosmic ray continuous recording programmes at Christchurch have been carried on and the E–W asymmetry experiment with the M.U. 2 recorder commenced. Examination of nuclear research plates has been concluded and an investigation into alpha particle stars in nuclear emulsion completed. Close pairs of low energy stars were revealed. The origin of these stars was shown to be radioactive contamination and the association of pairs of stars was examined.

Carter Observatory, Wellington, N.Z.

(Director, Mr I. L. Thomsen)

Compared to the previous year weather conditions were much more favourable for observation, except for the latter half.

From February to December, lectures and telescope demonstrations on clear evenings were given to the public on Fridays. Attendances totalled 3225. In addition, lectures were given to several societies and a number of popular newspaper articles supplied to the press.

The lecture room has been made available to the Royal Astronomical Society of New Zealand for local meetings, as well as for the Annual General Meeting on December 4.

Sunspot observations have continued as in previous years and the following are monthly mean values of sunspot numbers :

0·0, 0·7, 10·8, 0·6, 0·8, 0·4, 2·7, 9·3, 0·6, 7·4, 8·2, 5·4.

From this it is considered that observed minimum occurred in 1954 June, while the smoothed curve indicates 1954 April as minimum. Detailed reports were forwarded to Zürich Observatory.

Spectrohelioscope observations were made whenever possible, and reported to Meudon Observatory.

Occultation observations were made whenever possible and also collected from selected amateurs. They still await partial reduction before forwarding to H.M. Nautical Almanac Office.

The partial solar eclipse on January 5 was observed, but the times were not very good owing to the weather conditions at the time.

The following photographs were taken : Moon 4, Eta Carinae 3, Sun 5. A visual observation of Comet Abell, on its first appearance in the Southern Hemisphere, was secured. Six observations for the position of Neptune were made.

A large number of visual observations of Mars were made with the 9-inch telescope and are in process of reduction.

Auroral activity remained low, but there was an unexpected display on October 24 accompanied by ionospheric and magnetic disturbances. Nothing on the Sun could be correlated with it. All existing photographic material has been reduced and reported to the Air Force Cambridge Research Center, U.S.A., under contract. Reduction of visual records from 1930 onwards has been commenced.

Short-term ionospheric disturbance forecasts were issued to the Post and Telegraph Department, New Zealand Broadcasting Service, and the Royal New Zealand Navy. Owing to the very low level of solar activity, however, these forecasts have been entirely dependent on the 27-day recurrence pattern,

deduced from radio condition reports provided by the services, as well as magnetic index figures obtained from the Geophysical Observatory, Christchurch.

Information has been supplied to the press, radio, legal firms, architects and others when requested.

Canterbury University Observatory, N.Z.

As this observatory has only a 6-inch refractor in equatorial mounting with no camera equipment and no timepiece, the telescope is used only for the purpose of training surveying students and for meeting the interest of the general public in astronomy. Regular Friday evening sessions were held from February till December. The average attendance was higher than in recent years. At the time of the opposition of Mars over 800 people queued up for a view of this planet and for many weeks after the attendance was between 100 and 50.

Godlee Observatory

(*Curators, Manchester Astronomical Society*)

During 1954 the work at Godlee Observatory has proceeded on a very similar pattern to that of the previous year, although restricted rather more by adverse weather conditions, and by interruptions due to necessary repairs and overhauls, which are now practically completed.

As usual a considerable number of parties visited the Observatory from Institutions, Schools, Clubs and Youth Organizations, totalling several hundred persons. They spent the evenings on observational work when weather permitted, or failing this lantern lectures were provided. This branch of the work of the Observatory is becoming increasingly popular, and in addition many requests for outside lectures have been met by the Wardens of the Observatory. On Thursday evenings the Observatory is reserved for Members of the Manchester Astronomical Society.

Solar drawings are made daily when weather permits, and these are supplemented by drawings made by members of the M.A.S. with their own instruments. The June solar eclipse was viewed by one of the Wardens in Sweden, and by two in Shetland.

A small number of planetary drawings, and some lunar photographs have been made.

Mr R. Barker's Observatory, Cheshunt, Hertfordshire

Despite a most wretched observing year, owing to continued bad weather, a few records were obtained of Mars with the 12·6-inch Calver equatorial. The canali Djihoun, Hiddekel, Gihon, Protonilus, Thoth, Cerberus, Tartarus, Titan, Brontes, Araxes were clearly defined and identified and Pandorae Fretum and Deucalionis Regio showed distinctly, south of Sinus Sabaeus.

All the dark Maria were observed. No lunar observations of any value were made.

A Dall pancratic–Barlow eyepiece was employed.

Dr J. L. Haughton's Observatory, Charmouth, Dorset

Seven occultations were observed in the early part of the year, but the shocking weather prevented further ones being seen, as it also reduced the number of visitors (24) to less than a third of those in previous years.

The writer joined the R.A.S.–B.A.A. Eclipse Expedition to Sweden and obtained photographs of the total phase, and air temperatures during the eclipse. The record of these was published in the *Journal of the B.A.A.*

An apparatus has been devised, and preliminary experiments carried out, for determining the personal equation of occultation observations.

Meteorological observations have been carried out as usual and the rainfall records have been communicated to the British Rainfall Organization.

Mr M. B. B. Heath's Observatory, Kingsteignton, S. Devon

The Sun was observed on 50 days, regular daily observations having been commenced on October 1. Mercury was observed in daylight on 15 days and Venus on 88 days. The full disk of the latter was seen on January 31 when about 58½′ outside the solar limb. Mars was observed on 18 nights and 3 drawings made, Jupiter on 10 nights for timing various satellite phenomena and Saturn on 38 nights.

Mr F. M. Holborn's Observatory, Peaslake, Surrey

During 1954, 2002 observations of 71 variable stars and novae were made on 141 nights and a little work was done on comparison star sequences. The Sun was observed on 212 days for spot counts and naked-eye spots. All records were made for the British Astronomical Association except those of γ Cassiopeiae which were sent to the Norman Lockyer Observatory.

Mr Patrick Moore's Observatory, East Grinstead, Sussex

As in previous years, regular lunar and planetary work has been carried out with the 12½-inch reflector; results have appeared in the publications of the British Astronomical Association, and elsewhere. Apart from the Moon, Venus and Jupiter have been the main objects of attention, over 50 drawings being secured of the former.

Mr F. J. Sellers' Observatory, Muswell Hill, London

No routine observations have been made during 1954 but necessary repairs to the observatory and adjustments to the instruments have been attended to. The mirrors are being re-aluminized and it is intended that regular observations will be resumed in time for any marked recrudescence of solar activity. The minimum appears to have been recently reached.

Dr W. H. Steavenson's Observatory, Cambridge

The 30-inch reflector was used mainly for photometric observations of novae, especially Nova Persei. Physical observations were made of comets Pons-Brooks, Abell and Vozarova. As in other years, the telescope was occasionally used for demonstrations to undergraduates and other visitors to the University Observatories on " open " nights.

Dr R. L. Waterfield's Observatory, Ascot, Berkshire

During the year 20 plates were exposed on the comets Pons-Brooks, Abell, Kresak-Peltier, Vozarova and Baade for estimating magnitudes and recording physical features. Two of the plates of comet Baade were measured and reduced for the determination of positions. The results were communicated to the Director of the Comet Section of the B.A.A. Four lunar occultations were observed and communicated to H.M. Nautical Almanac Office. In addition a small number of micrometrical measurements of double stars were made; and on June 30 the writer observed his sixth total solar eclipse, on this occasion from an aeroplane over the North Sea.

Dr H. P. Wilkins' Observatory, Bexleyheath, Kent

During 1954 lunar and planetary observations were continued with the 15-inch reflector and the observatory was open on Saturday evenings to members of the Crayford astronomical circle sponsored by the Kent Education Committee.

The observatory was closed throughout June and July when I undertook a lecture tour in the United States, during the course of which the Bradley, Mt Wilson, Mt Palomar, Lick, Chabot, Yerkes, Washburn and Washington Observatories were visited.

The Moon, Mars and Saturn were observed with the Mt Wilson 60-inch reflector and the Washington 26-inch refractor. With the Yerkes 40-inch refractor, in addition to the satellite Deimos much detail was seen on Mars, including several "canals" and "oases". Numerous belts and some dark spots were observed on Saturn, also sub-divisions in rings A and B. Some faint detail was seen on the satellite Titan. Previously unrecorded lunar detail detected with the 60-inch reflector and the 26-inch refractor included clefts and pits in connection with Vendelinus, the Straight Wall and the Maria Crisium and Humorum.

REPORTS ON THE PROGRESS OF ASTRONOMY

SOLAR ACTIVITY

Sunspots.—The sunspot record of 1954 includes, quite definitely, the epoch of minimum of the solar cycle. The provisional mean sunspot number for the year is 4·2 as compared with 5·0 for the previous seven minima. Besides a general low level of activity, there have been the well-known indications of the petering-out of the old-cycle spots in equatorial regions and the increasing occurrence in latitude above 20° of the new-cycle spots with their reversal of magnetic polarities (*The Observatory*, **74**, 225, 1954). By the middle of the year, the lowest level of activity was probably reached, and this is reflected in the complete absence of disturbance features in the "minimum" corona seen during the total eclipse of June 30.

A time-pattern diagram of geomagnetic indices tells the same story. The last of the definite 27-day recurrence sequences (M-solar regions) had ended in 1953 December. Excepting the indications of a weak recurrence series that included a small storm on April 12, the diagram until late September is mainly featureless. Since then, there has been an increase in minor disturbance often accompanied by auroral glows seen northwards from the north of Scotland.

Individual sunspots call for little comment. With a few exceptions, they were small and short-lived. What was probably the last significant spot of the old cycle, with central meridian passage on March 17·2 and in latitude 8° S, grew from a small spot of 40 units on March 12 to a regular spot of 700 units (millionths of the Sun's hemisphere) by March 16. The two largest spots of the new cycle crossed the central meridian on November 9·3 (latitude 34° S and maximum area 250 millionths of the Sun's visible hemisphere) and December 15·4 (latitude 34° N and maximum area 300 millionths). At the time of the latter spot an increase in intensity of radiation on metre wave-lengths was reported.

Throughout the year, solar flares were rare, and those that occurred failed to produce any marked ionospheric effects. No geomagnetic crochet was recorded at Abinger; no short-wave radio fade-out was reported by Cable and Wireless Limited and no recognizable S.E.A. impulse (sudden enhancement of very long radio waves) appears on the Herstmonceux record. These negative records all supplement the observed lack of marked chromospheric activity associated with the sunspots of 1954. It is also known that, sharing in the decline to sunspot minimum, there has been a decrease in the intensity of solar radiation recorded on a wave-length of 10·7 cm. Interesting latitude changes in the occurrence of coronal emission (especially that at 5303 A) have been observed prior to sunspot minimum: (*a*) a low-latitude belt drawing towards the equator like the sunspots and (*b*) a high-latitude region recognizable some three years before minimum (*Comptes Rendus*, **239**, 1119, 1954).

The interval between the last two sunspot maxima of 1937·4 and 1947·5 (according to Zürich) is only 10·1 years. Should the epoch of the present minimum be substantiated as 1954·4, the interval between this and the preceding minimum will also be little more than ten years, viz. 10·2 years as compared with

11·0 for the average length of the past twelve cycles. Into those ten years have been crowded a remarkable succession of spots of all sizes and degrees of associated phenomena, including five giant spots that rank as the five largest in the whole eighty years of the Greenwich sunspot observations.

H. W. NEWTON

Prominences.—The mean daily areas and numbers of calcium prominences at the limb as derived from photographs taken at Kodaikanal are given below :

	Area in square minutes					Number				
1954	North	South	East	West	Total	North	South	East	West	Total
Jan.–June	0·80	0·47	0·55	0·72	1·27	2·67	2·39	2·18	2·88	5·06
July–Dec.	0·93	0·91	0·74	1·10	1·84	2·97	2·87	2·64	3·20	5·84
Whole year (weighted mean)	0·85	0·66	0·63	0·88	1·51	2·79	2·59	2·37	3·01	5·38

Compared with the previous year prominence activity as represented by areas shows a decrease of about 20 per cent while the numbers show a decrease of 23 per cent.

The distribution of areas in 5° ranges of latitude shows maximum activity in the zones 35° to 40° in both the hemispheres with a secondary maximum between 20°–25° in the northern and between 15°–20° in the southern hemisphere. There was very little activity beyond latitude 55° in the northern and beyond 50° in the southern hemisphere. The east–west distribution of areas and numbers showed a western excess.

Doppler shifts of the H-alpha line observed in prominences and absorption markings with the prominence spectroscope and spectrohelioscope are given below :

	North	South	East	West	To red	To violet	Both ways	Total
Prominences	45	25	27	43	1	3	66	70
Dark markings	15	3	10	8	1	...	17	18

The heights of nine prominences were measured in H-alpha, D_3 and H-beta lines with the prominence spectroscope. These were compared with the corresponding heights in the K line as obtained from the spectroheliograms. The average heights were :

K	H-alpha	D_3	H-beta
49″·5	47″·1	45″·4	36″·9

Only one instance of sudden disappearance of a hydrogen absorption marking was observed during the year.

The mean daily areas and numbers of hydrogen absorption markings on the disk as obtained from Kodaikanal records were as follows :

	Area (in millionths of the Sun's visible hemisphere) uncorrected for foreshortening					Number				
1954	North	South	East	West	Total	North	South	East	West	Total
Jan.–June	364·1	121·4	274·9	210·6	485·5	4·02	1·51	2·99	2·54	5·53
July–Dec.	500·6	131·7	301·7	330·6	632·3	3·76	1·35	2·34	2·75	5·09
Whole year (weighted mean)	422·6	125·7	286·1	262·2	548·3	3·91	1·43	2·70	2·63	5·34

Compared with the previous year there was considerable decrease in activity in both areas and numbers, the decrease in areas being about 51 per cent and the decrease in numbers 54 per cent.

The distribution of areas in 5° ranges of latitude shows maximum peaks of activity between 40° and 45° in both the hemispheres with very little activity beyond 55° in the northern and 50° in the southern hemisphere. Both areas and numbers show a slight eastern excess. A. K. DAS

DOUBLE STARS

New pairs.—Finsen (*The Observatory*, **74,** 41) gives new pairs discovered with the interferometer, Luyten (*P.A.S.P.*, **66,** 144) a new red–white dwarf binary.

Measures.—Measures of double stars are given by Baize (*J.O.*, **37,** 73), van Biesbroeck (*Yerkes P.*, **8,** pt. 6), Cester (*P. Trieste*, 254), Couteau (*J.O.*, **36,** 131 and **37,** 37), Djurkovic (*Bull. Obs. Belgrade*, **17,** 55 and **18,** 1), Jonckheere (*J.O.*, **37,** 13), Leone (*Contr. Milano-Merate*, No. 43), Luplau Janssen, Engelstoft and Wieth-Knudsen (*J.O.*, **36,** 107), Lyons and Wylie (*P. U.S. Naval Obs.*, 2nd ser., **17,** pt. 2), Muller (*J.O.*, **37,** 125 and errata **36,** 130), Pretre (*J.O.*, **37,** 25), Symms and Finch (*Greenwich Astr. Results*, 1939, B) and Wilson (*A.J.*, **59,** 132 and 256).

Orbits :

Double Star		*P*	*e*	*a*	Computer	Reference
				"		
ADS	34	108	0·58	0·41	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 4
,,	102	419	0·67	0·88	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 6
,,	102	310·345	0·586	0·698	Pensado	*Urania*, **39,** 87
,,	148	72·0	0·77	0·215	Baize	*I.A.U. Inf. Cir.*, 3
,,	293	200	0·80	0·444	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 11
,,	293	240	0·80	0·46	Muller	*J.O.*, **37,** 62
,,	363	54	0·65	0·365	Muller	*J.O.*, **37,** 62
,,	363	53·38	0·65	0·36	Baize	*J.O.*, **36,** 159
,,	684	143	0·52	0·42	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 17
,,	713	74	0·62	0·51	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 18
,,	784	76·5	0·30	0·24	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 20
,,	999	75	0·88	0·404	Muller	*I.A.U. Inf. Cir.*, 4
,,	1097	180	0·85	0·343	Muller	*J.O.*, **37,** 63
,,	11261	64	0·82	0·27	Muller	*I.A.U. Inf. Cir.*, 2
,,	11261I	112·5	0·25	0·191	Muller	*I.A.U. Inf. Cir.*, 2
,,	1613	12·71	0·58	0·12	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 32
,,	1615	720	0·60	2·665	Rabe	*I.A.U. Inf. Cir.*, 2
,,	1631	545·45	0·70	1·768	Rabe	*I.A.U. Inf. Cir.*, 2
,,	1737	150·0	0·72	0·57	Baize	*I.A.U. Inf. Cir.*, 3
,,	1860A'A–B	900	0·5	2·834	Rabe	*I.A.U. Inf. Cir.*, 2
,,	1860A'A–A	50	0·4	0·10	Rabe	*I.A.U. Inf. Cir.*, 2
,,	2034	356·4	0·0	1·16	Pensado	*Bol. Madrid*, **4,** 121
,,	2122	720	0·77	2·913	Rabe	*I.A.U. Inf. Cir.*, 2
,,	2173	78·26	0·21	0·41	Baize	*I.A.U. Inf. Cir.*, 4
,,	2373	51·2	0·43	0·273	Baize	*J.O.*, **36,** 160
,,	2373	51·0	0·48	0·27	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 41
,,	2416	866·6	0·595	1·916	Dommanget	*I.A.U. Inf. Cir.*, 1
,,	2524	25	0·18	0·148	Muller	*I.A.U. Inf. Cir.*, 2
,,	2612	221	0·66	1·11	van Biesbroeck	*Yerkes P.*, **8,** pt. 6, p. 43

Double Star		P	e	a	Computer	Reference
				"		
ADS	2765	141·9	0·26	0·328	Muller	*I.A.U. Inf. Cir.*, 4
,,	2768	63·14	0·20	0·332	Baize	*I.A.U. Inf. Cir.*, 4
,,	2959	450	0·68	2·338	Rabe	*I.A.U. Inf. Cir.*, 2
,,	3041	20	0·76	0·145	Muller	*J.O.*, **37**, 64
,,	3182	51·6	0·70	0·18	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. **51**
,,	3483	104·57	0·64	0·77	Baize	*J.O.*, **36**, 155
,,	4929	56·0	0·90	0·22	Baize	*J.O.*, **36**, 156
,,	4971 I	75·07	0·256	0·359	Wilson	*J.O.*, **37**, 21
,,	4971 II	28·00	0·890	0·520	Wilson	*J.O.*, **37**, 21
,,	5447	1057·8	0·613	1·536	Dommanget	*B.A.B.*, **4**, 152.
,,	5447	453	0·163	0·785	Ziller	*I.A.U. Inf. Cir.*, 4
,,	5949	56·96	0·273	0·33	Baize	*I.A.U. Inf. Cir.*, 4
,,	6354	18·46	0·50	0·20	Baize	*I.A.U. Inf. Cir.*, 4
,,	6549	160	0·52	0·32	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. **79**
,,	6650 AB	59·7	0·32	0·884	Gasteyer	*A.J.*, **59**, 243
,,	6650 CD, C	17·5	0·11	0·191	Gasteyer	*A.J.*, **59**, 243
,,	6650 AB, CD	1150	0·26	7·96	Gasteyer	*A.J.*, **59**, 243
,,	6825	40·0	0·10	0·22	Baize	*J.O.*, **36**, 161
,,	6828	51·0	0·50	0·30	Baize	*J.O.*, **36**, 162
,,	6851	31·0	0·85	0·47	Baize	*I.A.U. Inf. Cir.*, 3
,,	7067 I	1200	0·70	7·51	Rabe	*I.A.U. Inf. Cir.*, 3
,,	7067 II	900	0·70	6·23	Rabe	*I.A.U. Inf. Cir.*, 3
,,	7131	78·26	0·23	0·30	Baize	*J.O.*, **36**, 163
,,	7203	705·9	0·75	4·92	Rabe	*I.A.U. Inf. Cir.*, 3
,,	7251	1555·1	0·244	22·361	Hopmann	*I.A.U. Inf. Cir.*, 3
,,	7251	687	0·54	16·56	Güntzel-Lingner	*I.A.U. Inf. Cir.*, 4
,,	7307	389·05	0·291	1·516	Arend	*B.A.B.*, **4**, 158
,,	7555	78·39	0·653	0·372	Wierzbinski	*I.A.U. Inf. Cir.*, 3
,,	7685	143·7	0·90	0·609	Baize	*J.O.*, **36**, 164
,,	7724	618·6	0·843	2·505	Rabe	*I.A.U. Inf. Cir.*, 3
,,	7724	671·96	0·74	2·713	Güntzel-Lingner	*I.A.U. Inf. Cir.*, 4
,,	7744	222	0·46	1·37	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 98
,,	8032	115·00	0·66	0·65	Baize	*I.A.U. Inf. Cir.*, 4
,,	8148	204·5	0·55	1·960	Rabe	*I.A.U. Inf. Cir.*, 3
,,	8148	181	0·54	1·85	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 106
,,	8189	86·0	0·38	0·372	Muller	*I.A.U. Inf. Cir.*, 4
,,	8197	73·35	0·398	0·85	Hable	*I.A.U. Inf. Cir.*, 2
,,	8344	78·6	0·11	0·291	Baize	*J.O.*, **36**, 158
,,	8573	180	0·75	1·510	Muller	*I.A.U. Inf. Cir.*, 3
,,	8705	54·7	0·57	0·23	Baize	*I.A.U. Inf. Cir.*, 3
,,	8884	72·0	0·38	0·28	Muller	*I.A.U. Inf. Cir.*, 4
,,	8949	226·0	0·622	1·92	Florsch	*J.O.*, **37**, 124
,,	8987	22·33	0·52	0·217	Churms	*I.A.U. Inf. Cir.*, 2
,,	9019	368	0·452	0·935	Ziller	*I.A.U. Inf. Cir.*, 3
,,	9019	194·53	0·907	1·619	Arend	*B.A.B.*, **4**, 163
,,	9073	63·73	0·25	0·21	Baize	*J.O.*, **36**, 165
,,	9159	200·5	0·30	0·34	Baize	*J.O.*, **36**, 165
,,	9165	150·0	0·78	0·513	Muller	*I.A.U. Inf. Cir.*, 4
,,	9186	120	0·55	0·415	Muller	*I.A.U. Inf. Cir.*, 3
,,	9264	44·10	0·35	0·195	Baize	*J.O.*, **36**, 166
,,	9343	123·44	0·957	0·595	Wierzbinski	*I.A.U. Inf. Cir.*, 4
,,	9397	10·10	0·80	0·209	van den Bos	*I.A.U. Inf. Cir.*, 3
,,	9557	144	0·70	0·39	Baize	*J.O.*, **36**, 167
,,	9578	191	0·64	1·16	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 135
,,	9643	50	0·80	0·189	Muller	*I.A.U. Inf. Cir.*, 3
,,	9692	63·16	0·76	0·304	Muller	*J.O.*, **37**, 65
,,	9979	1000	0·78	6·599	Rabe	*I.A.U. Inf. Cir.*, 4
,,	10140	202·14	0·484	0·34	Baize	*J.O.*, **36**, 158

Double Star	P	e	a''	Computer	Reference
ADS 10561	45	0·54	0·205	Muller	*I.A.U. Inf. Cir.*, 2
,, 10585	60·0	0·18	0·60	Baize	*I.A.U. Inf. Cir.*, 3
,, 11060	20·0	0·97	0·27	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 159
,, 11574	48·2	0·62	0·146	Baize	*I.A.U. Inf. Cir.*, 4
,, 11632 a	313·04	0·60	10·681	Rabe	*I.A.U. Inf. Cir.*, 2
,, 11632 b	333·33	0·55	11·005	Rabe	*I.A.U. Inf. Cir.*, 2
,, 11632	2546·8	0·627	44·441	Hopmann	*I.A.U. Inf. Cir.*, 2
,, 11632	351·53	0·61	13·141	Güntzel-Lingner	*I.A.U. Inf. Cir.*, 4
,, 11791	628	0·68	0·847	Wilson	*I.A.U. Inf. Cir.*, 2
,, 11842	72	0·81	0·50	Muller	*J.O.*, **37**, 65
,, 12033	100	0·72	0·257	Muller	*I.A.U. Inf. Cir.*, 3
,, 12880	537·3	0·30	2·561	Rabe	*I.A.U. Inf. Cir.*, 2
,, 12889	243·55	0·78	1·478	Baize	*I.A.U. Inf. Cir.*, 4
,, 13728	90	0·92	0·214	Muller	*J.O.*, **37**, 66
,, 13850	83·72	0·77	0·172	Baize	*I.A.U. Inf. Cir.*, 4
,, 13944	48·25	0·47	0·166	Baize	*I.A.U. Inf. Cir.*, 4
,, 14099	94·7	0·30	0·235	Baize	*J.O.*, **36**, 168
,, 14396	30·0	0·89	0·246	Muller	*I.A.U. Inf. Cir.*, 4
,, 14412	59·30	0·52	0·18	Baize	*I.A.U. Inf. Cir.*, 4
,, 14424	92·0	0·25	0·44	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 189
,, 14775	78·35	0·173	0·166	Baize	*I.A.U. Inf. Cir.*, 4
,, 15267	85·0	0·31	0·28	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 197
,, 15300	41·38	0·23	0·15	Baize	*I.A.U. Inf. Cir.*, 4
,, 15378	21·0	0·41	0·16	Muller	*I.A.U. Inf. Cir.*, 3
,, 15971 A–BC	361·45	0·40	2·59	Rabe	*I.A.U. Inf. Cir.*, 2
,, 15971 BC–B	25·71	0·15	0·04	Rabe	*I.A.U. Inf. Cir.*, 2
,, 16046	60·9	0·57	0·210	Muller	*J.O.*, **37**, 68
,, 16057 I	785	0·546	2·042	Arend	*B.A.B.*, **4**, 167
,, 16057 II	156	0·611	0·790	Arend	*B.A.B.*, **4**, 167
,, 16157	108	0·30	0·403	Muller	*J.O.*, **37**, 69
,, 16278	144	0·18	0·181	Muller	*J.O.*, **37**, 70
,, 16314	124·14	0·12	0·277	Muller	*J.O.*, **37**, 70
,, 16326	90·0	0·82	1·066	Dommanget	*A. Obs. Belg.*, 3, **VI**, 45
,, 16345	100	0·50	0·69	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 209
,, 16345	106·67	0·51	0·736	Baize	*J.O.*, **36**, 170
,, 16345	104·5	0·54	0·647	Muller	*J.O.*, **37**, 71
,, 16345	102·27	0·53	0·68	Rabe	*I.A.U. Inf. Cir.*, 2
,, 16393	128·57	0·64	0·24	Muller	*I.A.U. Inf. Cir.*, 2
,, 16538	147·0	0·56	0·12	van Biesbroeck	*Yerkes P.*, **8**, pt. 6, p. 213
,, 16539	72·0	0·28	0·260	Muller	*I.A.U. Inf. Cir.*, 4
,, 16591	29·5	0·40	0·20	Baize	*I.A.U. Inf. Cir.*, 4
,, 16700	80	0·45	0·392	Muller	*I.A.U. Inf. Cir.*, 3
,, 16819	31·0	0·25	0·204	Muller	*I.A.U. Inf. Cir.*, 2
,, 16836	218	0·15	0·40	Widorn	*I.A.U. Inf. Cir.*, 3
,, 16836	144	0·45	0·38	Mato	*Urania*, **37**, 65
,, 17178	162·90	0·579	0·640	Dommanget	*A. Obs. Belg.*, 3, **VI**, 55
,, 17178 (pos. 1900)	148·5	0·443	0·615	Ziller	*I.A.U. Inf. Cir.*, 4
h m °					
1 30·4 −30	4·56	0·316	0·171	Wieth-Knudsen	*I.A.U. Inf. Cir.*, 3
6 32·4 −36	26·5	0·41	0·337	Finsen	*I.A.U. Inf. Cir.*, 2
8 54·2 +42	22·20	0·17	0·61	Baize	*I.A.U. Inf. Cir.*, 3
13 25·2 −38	62·6	0·33	0·155	van den Bos	*I.A.U. Inf. Cir.*, 2
14 40·5 −20	25·0	0·0	0·312	Finsen	*I.A.U. Inf. Cir.*, 2
17 11·5 −46	550	0·741	8·826	Wieth-Knudsen	*I.A.U. Inf. Cir.*, 3
19 12·5 −33	60·0	0·78	0·510	van den Bos	*I.A.U. Inf. Cir.*, 2
20 55·1 + 7	40	0·52	0·355	Muller	*J.O.*, **37**, 67
21 38·4 +40	19·5	0·16	0·157	Muller	*J.O.*, **37**, 68

Linear formulae are given by Couteau and van den Bos (*I.A.U. Inf. Cir.*, 3). Baize (*B.S.A.F.*, **68,** 22) writes a note on how to compute a double star orbit, Dommanget (*A. Obs. Belg.*, 3, VI, 41) gives an empirical method of improving the orbit of a visual binary, Muller (*I.A.U. Inf. Cir.*, 1–4) lists of double stars in need of re-measurement and of orbits planned, Rakowiecki (*Bull. Torun*, No. 12) formulae for computing the orbit and ephemeris of a visual binary and Vidal (*Urania*, **37,** 70) a description of auxiliary apparatus for computing double star orbits.

Miscellaneous.—Ashbrook (*The Observatory*, **74,** 213) has a note on hypothetical parallaxes of double stars, Strand (*A.J.*, **58,** 229) on dynamical parallaxes from photographic observations, Duke (*A.J.*, **59,** 184) on photographic blending of close binaries, Voûte (*J.O.*, **37,** 113) on the use of the reversing prism in measurements of double stars, Wilson and Moore (*A.J.*, **59,** 195) on an eyepiece interferometer for double star measurement. Hopmann gives a note on the magnitudes and colours of ADS 12345 (*Mitt. Wien*, **6,** 93), photometry of 420 visual double stars (*Mitt. Wien*, **6,** 105) and magnitudes and colours of visual double stars (*Mitt. Wien*, **6,** 209).

Muller gives statistics of magnitude differences in visual double stars (*B.A.*, **18,** 59), Wallenquist (*A. Uppsala*, **4,** No. 2) a general catalogue of magnitude differences. Struve (*Sky & Tel.*, **13,** 256 and 295) writes on spectra of visual double stars, Strand and Hall (*Ap. J.*, **120,** 322) on visual binaries for the mass–luminosity relation, Deitch (*A.J. U.S.S.R.*, **30,** 366) on the problem of the dark companion of 61 Cygni, Sharpless (*Ap. J.*, **119,** 334) on multiple-star systems in emission nebulae and Wesselink (*M.N.*, **113,** 505) on radial velocity observations and the parallax of α Centauri. Jonckheere has notes on double stars extracted from the Astrographic Catalogues (*J.O.*, **37,** 31), the aim of double star measures (*The Observatory*, **73,** 245) and a review of van Biesbroeck's latest series of double star measures (*The Observatory*, **74,** 132). Jackson (*The Observatory*, **74,** 77) writes on the measurement of double stars and Strand (*A.J.*, **59,** 61) on the present status of double star astronomy.

W. H. VAN DEN BOS

COMETS (1954)

The twenty comets observed in 1954 included six new ones, and five periodic comets whose returns had been predicted. The two annual comets and seven of the discoveries of the previous year were also under observation.

The annual comet Schwassmann-Wachmann (1) was observed at Yerkes in February, March and May as a diffuse coma of magnitude 16·5–17. It was seen at Lick on March 4 and April 29, on which date the comet had a faint fan-shaped coma extending 0′·5 west of an 18th magnitude nucleus. Although no outbursts of light are indicated during the current year, plates taken at Sonneberg with the Schmidt camera reveal two outbursts (previously reported) on 40 plates taken up to 1953 May 20. Comet Oterma was observed at Yerkes (August 10) and at McDonald (October 24). It showed a faint narrow tail 40″ long (magnitude 19) and a Palomar Sky Survey plate recorded the same appearance on August 30. Plates taken at Lick in July, August and September all show a nearly stellar nucleus of magnitude 17·5 with a faint slender tail 0′·5 long towards position angle 250°.

1953 a, Mrkos-Honda, was last seen at Lick on January 1.

(*Observations* 1953 *April* 12 *to* 1954 *January* 1)

1953 b, P/Brooks (2), was recorded on February 5 (magnitude 19, Van Biesbroeck) at McDonald.
(*Observations* 1953 *June* 18 *to* 1954 *February* 5)

1953 c, periodic comet Pons-Brooks, remained at about magnitude 11 during January and February, but showed another surge of brightness during March—the fourth such rise since discovery. It seems likely that this comet will provide much material for study. At Sonneberg 83 plates, including 70 with the Schmidt camera, were taken up to March 9; these include three pairs of plates taken with different colour filters, and three exposures with a 3-degree objective prism. A long series of visual photometric observations was also made by Max Beyer at Bergedorf. The general impression is given that the comet was less bright than was expected. It was last seen at Yerkes on April 23, when the magnitude was estimated at 6·4; a tail 30′ long, pointing northwards, could be seen in spite of the low altitude. This description is confirmed by Beyer, but his magnitude estimate would make the comet brighter than this. A. Jones reported the comet in New Zealand on June 22, and the last measures appear to be those at Cordoba on September 4.
(*Observations* 1953 *June* 20 *to* 1954 *September* 4)

1953 d, periodic comet Reinmuth, was recovered in July and plates were taken at Lick and Yerkes. The comet was round, about 0′·2 in diameter, magnitude 17 to 18. A faint tail extension in position angle 20° was reported by Van Biesbroeck on October 26. The last observation was made in November at Lick.
(*Observations* 1953 *July* 5 *to* 1954 *November* 25)

1953 f, periodic comet Encke, was seen on February 4–5 at McDonald as a small round nebulosity of magnitude 19. It was also reported in July by A. Jones and a position is given by Bruwer at Johannesburg on July 27 in *UAIC* 1480.
(*Observations* 1953 *September* 3 *to* 1954 *July* 27)

1953 g, Abell, was under almost continuous observation until September 16, when it was last seen at Cordoba. At the beginning of the year it was of magnitude 12·5 and it continued to grow brighter. In May, magnitude estimates vary from 9 to 11, and at Yerkes the comet was seen to have a coma 2′ in diameter, and a complex tail structure. There was a well-defined narrow tail some 12′ in length in position angle 64° (also mentioned by Beyer) and a shorter and much broader streamer towards 340°—almost at right angles to the first. The whole sector between the two tails was filled with material streaming from the nucleus. The same structure persisted into June, and is described in detail by Abell in *P.A.S.P.*, **66**, 253, 1954. The comet was photographed on June 30 with the 48-inch Schmidt camera at Palomar, its magnitude being estimated at about 6. The magnitude estimates at this time are, however, very discordant. The comet was subsequently seen in the southern hemisphere, particularly in New Zealand, Johannesburg, and Cordoba. At Sonneberg, 68 plates of this comet were taken up to May 27, including a number with colour filters, and some with the objective prism. Beyer has recorded another long series of visual estimates of brightness, and positions have been measured at many European observatories.
(*Observations* 1953 *October* 15 *to* 1954 *September* 16)

1953 h Pajdušáková had faded completely and was not found in spite of searches at Heidelberg, Bergedorf and Yerkes.
(*Observations* 1953 *December* 3 *to end of* 1953 *only*)

1953 i, periodic comet Finlay, was photographed on March 4 at Lick as a moderately condensed round nebulosity 0′·3 in diameter, of magnitude 17. It was last seen by Van Biesbroeck at Yerkes on April 1.
(*Observations* 1953 *December* 7 *to* 1954 *April* 1)

1954 a, periodic comet Honda-Mrkos-Pajdušáková 1948 XII, was recovered by Van Biesbroeck on a pair of plates taken by Miss D. Jehoulet with a 5-inch Ross lens at McDonald Observatory on February 4. It was later learned that the comet had been located by T. Mitani at Kwasan on January 28. The elements of the 1948 orbit were uncertain and the unexpected fading of this comet after its previous perihelion passage made any estimate of its magnitude doubtful. Ephemerides based on various assumptions were published by Merton, and these led eventually to the recovery of this short-period comet. At the time of recovery, the poorly defined coma of diameter about 1′ had a faint narrow tail that could be traced to a distance of 12′ in position angle 75°. On February 8 the comet showed a similar appearance on a Lick photograph, but it had faded to magnitude 11·5 by February 20. When last seen at Lick on March 31 it was difficult to measure, having a weak nucleus in a round diffuse coma of diameter 0′·4, magnitude 17. It was seen at Yerkes on April 1, but no trace of the comet was found on April 23, when it must have been fainter than magnitude 18.
(*Observations January* 28 *to April* 1)

1954 b, periodic comet Borrelly, which has not been seen since 1932, was recovered by Elizabeth Roemer at Lick on February 8, after several unsuccessful searches. The magnitude was estimated at 18·5, and the comet had a sharply defined coma with a distinct tail in a north-west direction. At McDonald, Van Biesbroeck recorded the comet on February 26 and March 2 as a round diffuse coma of magnitude 19. Two plates obtained at Lick on March 4 with a two hour exposure showed the comet as a slightly diffuse object of magnitude 19·5. No further measures have been reported.
(*Observations February* 8 *to March* 4)

1954 c, the first new comet of the year, was discovered by Robert G. Harrington on two photographs taken for the NGS–Palomar Sky Survey on June 24 with the 48-inch Schmidt camera. Following the discovery of a comet at this observatory, an attempt is made to obtain three further observations with the same telescope. On this occasion the observations of June 25, 26 and 28 were communicated to Cunningham at the Leuschner Observatory, and these form the basis of his preliminary orbit. The comet at discovery was a diffuse object of magnitude 19. Six further plates were taken at Lick by Miss Roemer, and it should therefore be possible to improve the initial elements. On July 31 the comet, of magnitude 18·5, had an almost stellar appearance, while the last observation on August 31 showed a diffuse coma of diameter 0′·2 and magnitude 19.
(*Observations June* 24 *to August* 31)

1954 d was found on June 26 by L. Kresák at Skalnaté Pleso in the course of systematic searches with the 4-inch Somet-Binar binoculars. The comet was independently discovered by L. G. Peltier on June 29—the twelfth cometary discovery that he has made. It appeared as a large round nebulosity with an eccentrically placed nucleus of magnitude 8·4 (Beyer). It was photographed at Lick on June 30 and was also seen in the 36-inch refractor, but was so diffuse as to be more readily visible in the 4-inch finder than in the large telescope. In the early days of July observations of the comet were made at many centres, and all agree that the large diffuse coma of 10′ or more in diameter was of about magnitude 9. The comet then seems to have faded rapidly; and although it was seen at Yerkes and Johannesburg, Bruwer reported it as diffuse and difficult on July 31. Three observations were made in August at Cordoba, and a Lick photograph on October 9 with a 5-minute exposure showed a round coma 1′ in diameter with a poorly defined nucleus, magnitude 13. The last observation seems to be that of Kresák at Skalnaté Pleso on October 24, and no trace of the comet was found on October 29 (Skalnaté Pleso), October 30 (Greenwich), November 25, 29and 1955 January 15 (Lick—the last with 70 minutes' exposure).
(*Observations June 26 to October 24*)

1954 e, periodic comet Faye, was recovered by Van Biesbroeck on plates taken with the 24-inch reflector at Yerkes on July 25. It then presented an almost stellar image, slightly elongated, and of magnitude 17. A plate taken on July 1 at Lick also shows the comet with a nearly stellar coma and a faint tail 0′·8 long in position angle 260°, magnitude 17·8. The comet grew somewhat brighter and reached magnitude 16 in August and 15 in November. On December 24 (Yerkes) it was of magnitude 14, and had a tail 45″ long in position angle 65°. The comet was still under observation in 1955 January–February.
(*Observations July 25 to end of year, continuing*)

1954 f was discovered by Miss Margaret Vozárová (now Mrs Kresáková) at Skalnaté Pleso on July 28 in the course of systematic searches. The comet was of magnitude 9·5 and had no visible tail or nucleus. It was observed at many places during the succeeding weeks, but seems to have faded rather rapidly. On August 2 it was photographed at Sonneberg and at Skalnaté Pleso, and then showed a narrow straight tail about 10′ long directed *towards* the Sun (position angle 155°) with only a short prolongation in the opposite direction. Van Biesbroeck at Yerkes also recorded a slender tail 15′ long in position angle 160° in August, and estimated the magnitude as about 9·5. Beyer followed it at Bergedorf until September 27, but it was not seen there on October 3. At Lick on September 30 it appeared as a round coma 0′·2 in diameter, magnitude 16, and had a faint fan-shaped tail 0′·7 long in position angle 60°. At McDonald, using the 82-inch reflector, Van Biesbroeck observed the comet on October 27; it was then of magnitude 16·5 and still showed a trace of tail in position angle 95°. The last observation appears to be a Lick photograph on December 18, when the comet appeared as a stellar coma of magnitude 18·5.
(*Observations July 28 to December 18*)

1954 g, periodic comet Schwassmann-Wachmann (2), was recovered by H. M. Jeffers and Miss Roemer at Lick on July 28. It then appeared as a small nearly stellar coma of magnitude 18, but it became brighter in the next few

months and at the end of October (Lick) was of magnitude 16 with a faint fan-shaped tail 0′·5 long. It was still under observation at the end of the year, in a good position, and displayed a broad tail 1′ long in position angle 280°.
(*Observations July 28 to end of year, continuing*)

1954 h was discovered by Walter Baade on two 48-inch Schmidt plates taken for him by George O. Abell at Palomar on July 31. The comet was then in Ursa Minor, and was a diffuse object of magnitude 15 with a short tail in position angle 135°. It had brightened to magnitude 15 by the end of November (Lick); on December 24 it was estimated at magnitude 13 (Yerkes) and still had a short broad tail. Since perihelion passage does not occur until 1955 August, this circumpolar comet may be expected to grow brighter and be observable over a long period.
(*Observations July 31 to end of year, continuing*)

1954 i was discovered by Van Biesbroeck on September 1 on a pair of plates taken with the 24-inch reflector at Yerkes. The plates were exposed in order to locate the minor planet 1953 GC; this object was not found, but the comet appeared in its place. It showed a small round coma, fairly well condensed, of magnitude 15, and it was moving quite slowly near the ecliptic. Some difficulty arose in determining the elements from the initial short arcs, but an orbit by Cunningham, using a 27-day arc, showed that this was another periodic comet with a small inclination and a period of 14 years. The comet was followed at Yerkes until November 28 (magnitude 18·5, small round coma 3″ diameter), but a later photograph at Lick on 1955 January 15 shows a nearly stellar object of magnitude 19. The position agrees well with Cunningham's original orbit, but it is understood that revised elements give a period of 12·4 years. Further observations may be possible at the opposition of 1955 October.
(*Observations September 1 to end of year, continuing*)

1954 j is the return of periodic comet Wirtanen, 1947 XIII, and it was recovered by C. A. Wirtanen himself on a plate taken with the 20-inch astrograph at Lick on September 8. The faint image could not be confirmed until September 26, when measures of the diffuse image were made by Jeffers with the Crossley reflector. The recovery of this comet is particularly gratifying and arises from Merton's work on the 1948 orbit. Using Lick observations covering 54 days, he computed a new orbit which had a period 6½ months shorter than that given originally by Cunningham. The comet would therefore be at perihelion in the autumn of 1954, and the application of approximate perturbations computed by W. E. Beart gave a value of $T = 1954$ August 15. These values enabled ephemerides to be computed and led to the successful recovery of the comet within 1′ of the predicted place. The comet was last recorded by Van Biesbroeck at McDonald on October 26 as an extremely diffuse coma 30″ in diameter and magnitude 19, and also at Lick on October 28, where the images of magnitude 19·5 were difficult to measure. An exposure of two hours at Lick on 1955 January 27 failed to show the comet.
(*Observations September 8 to October 28*)

1954 k was discovered on the night of December 17–18 at Tonantzintla Observatory by Guillermo Haro, the Director of the Tonantzintla and Tacubaya Observatories, and Enrique Chavira, Assistant Astronomer. The Schmidt

camera (26-inch correcting plate, 32-inch mirror) was being used in the study of flare stars in the dark clouds in Taurus, and on each plate five exposures are given of 10 minutes each in order to detect rapid variations in brightness of any of the stars in the field. The discovery plate thus shows five images of the comet, and it was measured at Yerkes by Van Biesbroeck. It showed a well condensed coma 15″ in diameter with a faint tail 30″ long in position angle 200°, the magnitude being 15·5. The comet was observed at Lick and Yerkes early in 1955 and is likely to be under observation for some time.
(*Observations December 17 to end of year, continuing*)

Unsuccessful searches were made during the year at Lick, Yerkes, McDonald and other observatories for comets 1953 a, 1953 e, 1953 h, and for periodic comets Neujmin (2) and Olbers. The return of the last of these had been predicted by Rasmusen, but Van Biesbroeck failed to find it on October 4 with the 82-inch at McDonald, although stars down to magnitude 20 were recorded.

The numerical designation of comets (in order of perihelion passage) has recently been extended by the I.A.U. Bureau (*UAIC* 1490, 1493). The list that follows continues that given in *M.N.*, **114**, 366, 1954. The perihelion dates (*T*) are from orbits noted in these annual reports.

Comet	*T*	Name	Year and letter
1950 I	Jan. 19·3	Johnson	1949 a
II	June 6·4	P/d'Arrest	1950 a
III	July 15·7	P/Oterma	...
IV	July 22·7	P/Reinmuth (1)	1949 f
V	Aug. 23·8	P/Daniel	1950 d
VI	Oct. 23·6	P/Wolf (1)	1950 c
VII	Dec. 18·9	P/Arend-Rigaux	1951 b
1951 I	Jan. 15·0	Minkowski	1950 b
II	Jan. 30·5	Pajdušáková	1951 a
III	Mar. 16·2	P/Encke	1950 e
IV	May 9·4	P/Tuttle-Giacobini-Kresák	1951 f
V	May 26·9	P/Neujmin (3)	1951 g
VI	Sept. 8·7	P/Pons-Winnecke	1951 c
VII	Oct. 20·4	P/Kopff	1951 e
VIII	Oct. 25·5	P/Tempel (2)	1951 d
IX	Oct. 30·4	P/Harrington-Wilson	1952 a
X	Nov. 23·3	P/Arend	1951 j

The table giving the elements of cometary orbits is arranged very much as in previous reports. Comets are listed in order of perihelion date; the symbol P/ indicates a periodic comet, and *p* after the perihelion date that the elements were predicted ones. The perihelion date deduced from observations in such a case will be found in the notes appended.

Elements of

Ref.	Comet		T (U.T.)	q	e
(1)	1930 III	Wilk	1930 Mar. 28·7997	0·481809	0·992193
(2)	1930 VI	P/Schw.-Wach. (3)	1930 June 14·1953	1·011426	0·672673
(3)	1932 V	Peltier-Whipple	1932 Sept. 1·8571	1·037210	0·976549
(4)	1946 V	P/Giacobini-Zinner	1946 Sept. 18·4991	0·995677	0·716677
(5)	1947 XIII	P/Wirtanen	1947 Dec. 2·9305	1·634940	0·540492
(6)	1948 XI	Eclipse Comet	1948 Oct. 27·4271	0·135420	0·999935
(7)	1950 VI	P/Wolf (2)	1950 Oct. 23·6522	2·497584	0·396372
(8)	1954 b	P/Borrelly	1953 June 8·7304	1·448467	0·604383
(9)	1954 c	Harrington	1954 Jan. 18·8727	2·113315	1·0
(10)	1954 a	P/Honda-Mrkos-P.	1954 Feb. 6·2*p*	0·55552	0·81520
(11)	1954 *i*	P/Van Biesbroeck	1954 Feb. 11·7726	2·353287	0·597467
(12)	1953 c	P/Pons-Brooks	1954 May 22·8905	0·773930	0·954802
(13)	1954 f	Vozárová	1954 June 1·9343	0·677080	1·0
(14)	1953 g	Abell	1954 July 7·3648	0·969964	1·0
(15)	1954 j	P/Wirtanen	1954 Aug. 13·621*p*	1·625156	0·542106
(16)	1954 d	Kresák-Peltier	1954 Aug. 29·6718	0·746437	1·0
(17)	1954 g	P/Schw.-Wach. (2)	1955 Feb. 27·292*p*	2·150081	0·384536
(18)	1954 e	P/Faye	1955 Mar. 3·582*p*	1·651866	0·565249
(19)	1954 h	Baade	1955 Aug. 13·2109	3·870352	1·0
(20)	1954 k	Haro-Chavira	1956 Feb. 4·2663	3·861266	1·0

References and Notes to Table of Elements

(1) Comet Wilk, 1930 III. G. Schrutka-Rechtenstamm, *Mitt. Univ.-Stern. Wien*, **6**, 175, 1953. Definitive, revised (differing from *UAIC* 1081) including perturbations Venus to Saturn; 174 observations arranged in 11 normal places, arc of 102 days.

(2) Comet P/Schwassmann-Wachmann (3), 1930 VI. D. Kalnina, *Astr. Circ.* (*U.S.S.R.*), No. 145, *UAIC* 1447.

(3) Comet Peltier-Whipple, 1932 V. G. Schrutka-Rechtenstamm, *Mitt. Univ.-Stern. Wien*, **7**, 41, 1954. Definitive, 353 observations in 17 normal places, arc of 140 days. The mean of the three best sets of elements is given here.

(4) Comet P/Giacobini-Zinner, 1946 V. C. Dinwoodie, *Handbook B.A.A.*, 1952. Revised orbit by differential correction of F. R. Cripps's elements, using selected 1946 observations.

(5) Comet P/Wirtanen, 1947 XIII. G. Merton, *UAIC* 1474. Revised elements based on 9 observations, 54-day arc.

(6) Eclipse Comet, 1948 XI. W. P. Hirst, *M.N.(A.S.S.A.)*, **13**, 33, 1954. Definitive, including perturbations Venus to Saturn, 120 observations in 27 normal places, arc of 146 days.

(7) Comet Wolf (1), 1950 VI. M. Kamienski, *MS.* Definitive, representing all observations 1925 to 1951.

(8) Comet Borrelly, 1954 b. M. Sumner, *MS.* New elements based on 10 observations over 24 days, with approximate perturbations 1932 to 1954.

(9) Comet Harrington, 1954 c. L. E. Cunningham, *UAIC* 1464. Preliminary elements, arc of 3 days only.

(10) Comet P/Honda-Mrkos-Pajdušáková, 1954 a. G. Merton, *UAIC* 1428. Predicted elements based on 1948 orbit with approximate perturbations by Jupiter and Saturn. Observations indicate T = Feb. 5·087 U.T.

(11) Comet P/Van Biesbroeck, 1954 i. L. E. Cunningham, *UAIC* 1478. Preliminary elements from 27-day arc.

Cometary Orbits

Period (years)	ω	Ω	i	Equinox	Epoch of Osculation	Ref.
485	46·9499	90·2627	67·1419	1930·0	1930 Apr. 2·0	(1)
5·43	192·3189	76·7814	17·4036	1930·0	1930 June 10·0	(2)
294	38·4715	344·5130	71·7120	1932·0	1932 Aug. 19·0	(3)
6·59	171·8310	196·2833	30·7302	1950·0	1946 Sept. 17·0	(4)
6·71	343·5184	86·5099	13·3562	1950·0	...	(5)
...	107·2618	210·3318	23·1222	1950·0	1948 Nov. 25·0	(6)
8·42	161·1456	203·8793	27·3162	1950·0	1950 Oct. 6·0	(7)
7·01	350·7279	76·2147	31·1125	1950·0	1954 Feb. 27·0	(8)
...	4·0200	293·0229	136·9208	1954·0	...	(9)
5·21	184·117	233·088	13·197	1950·0	...	(10)
14·1	129·9095	149·3283	6·8236	1954·0	...	(11)
70·86	199·0233	255·1913	74·1782	1950·0	1953 July 22·0	(12)
...	357·2280	122·1855	116·1581	1954·0	...	(13)
...	194·4015	2·3985	53·2215	1954·0	...	(14)
6·69	343·5189	86·4854	13·3772	1950·0	1954 Aug. 14·0	(15)
...	254·7209	74·9229	88·5568	1954·0	...	(16)
6·53	357·8555	126·0080	3·7250	1950·0	1955 Feb. 22·0	(17)
7·41	200·5715	206·3125	10·5533	1950·0	1955 Mar. 4·0	(18)
...	144·6537	264·6960	100·3908	1954·0	...	(19)
...	61·4923	72·2918	77·9558	1955·0	...	(20)

(12) Comet P/Pons-Brooks, 1953 c. Peter Musen, *HAC* 1249. Elements from current observations (independent of prediction or previous apparition). Eight observations, arc of 293 days, including perturbations by Jupiter.

(13) Comet Vozárová, 1954 f. I. Hasegawa, *UAIC* 1486. From 19 observations in 3 normal places, arc of 90 days.

(14) Comet Abell, 1953 g. S. Kanda, *UAIC* 1478. From 8 observations in 3 normal places, arc of 248 days.

(15) Comet P/Wirtenan, 1954 j. W. E. Beart, *MS.* Prediction from Merton's 1948 elements (ref. (5) above) with perturbations by Jupiter and Saturn. Observations indicate T=Aug. 13·54 U.T.

(16) Comet Kresák-Peltier, 1954 d. G. Merton, *B.A.A. Circular* 355. Preliminary elements, 6 observations, arc of 12 days.

(17) Comet P/Schwassmann-Wachmann (2), 1954 g. C. Dinwoodie, *MS.* Corrected values of his prediction in *Handbook B.A.A.*, 1954. Observations indicate T=Feb. 27·126 U.T.

(18) Comet P/Faye, 1954 e. W. E. Beart, *Handbook B.A.A.*, 1954. Based on Cunningham's 1947 elements with perturbations by Jupiter and Saturn. Observations indicate T=March 4·636 U.T.

(19) Comet Baade, 1954 h. L. E. Cunningham, *UAIC* 1489. From 3 normal places, arc of 109 days.

(20) Comet Haro-Chavira, 1954 k. L. E. Cunningham, *UAIC* 1489. Represents 6 observations, arc of 9 days.

Additional Notes

Individual Comets

1898 VII Coddington-Pauly. Erik Sinding: "The future orbit of Comet 1898 VII (Coddington-Pauly)", *Pub. Copenhagen Obs.*, No. 161, 1953.

1908 III Morehouse. P. Stumpff has a note on "Motion in the tail of Comet Morehouse" in *Mitt. der A.G., 1953*, 17 (10), 1954.

1916 I P/Taylor. V. A. Bronshten : " Comet Taylor 1916 I ", *Ast. Circ.* (*U.S.S.R.*), No. 149, 1954. He suggests identity of the two parts of this comet with 1951 b (=1950 VII P/Arend-Rigaux) and 1952 a (=1951 IX P/Harrington-Wilson).

1925 II P/Schwassmann-Wachmann (1). N. Richter : " Outbursts of brightness of Comet 1925 II and their relation to the sun's activity ", *Ast. Nach.*, **281**, 241, 1954. See also a note by the same author in *Mitt. der A.G., 1953*, 16 (9), 1954.

1925 VII Shajn-Comas Solá. I. V. Galibina : " Determination of original orbit of Comet 1925 VII ", *Bull. Inst. Theor. Astron.*, **5**, 412, 1953. He obtained $1/a = +0{\cdot}0000662$, 1913 March 13, using integration of rectangular coordinates. M. Y. Shmakova : " Investigation of the form of the orbit of Comet 1925 VII (Shajn-Comas Solá) ", *ibid.*, p. 420. She confirmed Galibina's work fairly closely back to 1919, by numerical integration of Lagrangian equations. Both started from Sakk and Kulikoff's definitive orbit for 1925.

1930 IV Beyer. M. A. Dirikis : " The determination of the original orbit of Comet 1930 IV Beyer ", *A.J.* (*U.S.S.R.*), **31**, 461, 1954. He found original $1/a = +0{\cdot}0005$.

1950 VII P/Arend-Rigaux. See 1916 I above.

1951 IX P/Harrington-Wilson. See 1916 I above.

1952 b P/Grigg-Skjellerup. A. F. Jones : " Comet P/Grigg-Skjellerup ", *Southern Stars*, **16**, 28, 1954. He gives magnitude estimates for the 1947 and 1952 apparitions.

1951 i Wilson-Harrington. A. F. Jones : " Comet Wilson-Harrington ", *Southern Stars*, **16**, 56, 1954. Magnitude estimates.

General

O. V. Dobrovolsk : " Electrostatic fields in the heads of comets ", *A.J.* (*U.S.S.R.*), **31**, 167, 1954.

—— " Ionisation in comets "; *ibid.*, p. 324.

A series of papers by this author appears in *Bull. Stalinabad Obs.*, Nos. 9, 10, 11, 1954 : these deal with the photometry, polarized light and illumination of comets, acceleration in tails of comets, and statistics of comets.

I. Dominski at Poznan has carried the orbit of 1925 I Orkisz back to 1919 and finds the original orbit an ellipse in agreement with the work of E. Strömgren.

M. Kamienski continues his exhaustive studies of P/Wolf (1) and his work on P/Halley, which he hopes to carry back to 2320 B.C.

F. Kepinski continues his calculations on P/Kopff, with the assistance of M. Bielicki. The main part of this work, linking the six apparitions of this comet, has already been completed, but the close approach to Jupiter in 1954 (within 0·1 unit) will entail much laborious calculation.

H. Hurnik (Poznan) has investigated the distribution of the perihelia of 451 comets, with conclusions that are in good agreement with those of S. Oppenheim, but which do not confirm those of M. Bourgeois.

E. N. Kramer. " Cometary radiants and the connection of meteor streams with comets ", *Kiev Astron. Obs. News*, **3**, 163, 1954.

—— " List of most reliable cometary radiants ", *Astr. Circ.* (*U.S.S.R.*), No. 143, 1953.

—— " Tisserand's criterion applied to comets and meteor streams ", *Astr. Circ.* (*U.S.S.R.*), No. 153, 1954.

N. B. Richter : *Statistik und Physik der Kometen* (Leipzig, J. A. Barth Verlag, 1954).

Vl. Vanysek and F. Hrebik : " The dependence of the photometric constant n of comets on the heliocentric distance ", *Bull. Astr. Inst. Czechoslovakia*, **5**, 65, 1954.

T. V. Vodopyanova : " The absolute magnitudes of comets ". This is a continuation of Vsessviatsky's lists, and values for the comets of 1947 to 1952 appear in *Astr. Circ.* (*U.S.S.R.*), Nos. 145, 147, 150; 1954.

J. G. PORTER

THE PRESIDENT'S ADDRESS

ON THE AWARD OF THE GOLD MEDAL TO PROFESSOR DIRK BROUWER

Dr John Jackson

The Gold Medal of the Society has been awarded by Council to Dirk Brouwer, Professor of Astronomy at Yale University and Director of Yale University Observatory, for his outstanding contributions to Celestial Mechanics.

Brouwer studied astronomy at Leiden under Professor de Sitter and obtained his doctor's degree for his discussion of the many observations of the four great satellites of Jupiter made at the Union Observatory, Johannesburg between 1908 and 1925. The results were published in the *Annals* of Leiden Observatory and played an important part in de Sitter's theory of the motions of these satellites. From Leiden Brouwer went to Yale to be colleague and successor to Professor E. W. Brown who, like de Sitter, had been awarded our Gold Medal for work on Celestial Mechanics. Brown's *Tables of the Moon* had been introduced into the *Nautical Almanac* in 1923 and when Brouwer went to Yale he found great activity there in discussing the many observations of occultations which had been recently made with the object of affording a check on the accuracy of the tables. The occultations showed a term of yearly period in the difference between the observed and predicted longitude of the Moon. This might be due to (*a*) an error in the theory or tables, (*b*) a systematic error in the right ascensions of the stars depending on the right ascension, or (*c*) an annual irregularity in the rotation of the Earth. No error could be found in the tables and while Brown at first attributed the discordance to irregular rotation of the Earth Brouwer showed that erroneous star places contributed to the result. It is interesting to note that it has been shown recently that part of the difference in time between astronomical observations and quartz clocks can be attributed to the same insidious errors in star places.

As is well known, Brown's theory is now considered so nearly perfect that we attribute the outstanding differences between theory and observation to irregularities in the rotation of the Earth. A secular term can be explained by tidal friction in the shallow seas. When this and the mean motion are adjusted to give the best fit possible between theory and observation there remains a "fluctuation" which automatically reaches its greatest value sometime during the interval covered by accurate observations. Geophysicists have suggested various explanations of the fluctuation. Our medallist has treated the subject mathematically and shown that fluctuations of the observed amount and nature could arise from cumulative random changes in the rate of rotation of the Earth, whatever the cause of these changes.

Brouwer has given a good deal of attention to minor planets. Ever since the discovery of the second of them there has been much speculation on their origin and the possibility of their being the result of collision or explosion, although it has been recognized that the original orbits must have been greatly altered in shape and inclination by perturbations of the major planets. The discovery by

Kirkwood that there were gaps in the rings corresponding to simple commensurability with the mean motion of Jupiter indicated that in some way the giant planet exerted a systematic influence on them. The adjustment of the orbital elements for secular variations in the elements of the major planets led Hirayama more than thirty years ago to the discovery of families of minor planets. As a preliminary to other work Brouwer, with A. J. J .van Woerkom, recalculated with revised masses the secular variations of all the major planets. Brouwer then proceeded to revise and extend Hirayama's work to 1537 of the numbered minor planets. He was thus able to make a more systematic study than had previously been possible of the existence of groups of minor planets. He verified the existence of other groups from close agreement of mean motion, eccentricity, inclination and sometimes also longitude of node and perihelion. Three of the families have each more than fifty members. Brouwer concludes: " On the whole it appears to me that the evidence is favourable to the collision theory in a qualitative way. Further testing can be made only after elaborate calculations have been completed ".

The positions of the planets given in our almanacs have been computed from tables constructed from time to time by outstanding workers in the field of celestial mechanics. These culminated during the second half of last century in the compilation at Washington of the tables still in use. Although the tables on the whole fit the observations pretty closely we know that certain elements require correction and what is worse the theories are not quite complete.

A new phase in the calculation of the motion of bodies in the solar system followed the discovery of the eighth satellite of Jupiter at Greenwich in 1908. This satellite is so distant from its primary that the solar perturbations are of the order of one-tenth of the central force and no algebraic solution of the equations of motion was available for dealing with this situation. Hitherto mechanical quadrature (or numerical integration) had only been used for the calculation of the perturbations, but Cowell decided that as the perturbations were of nearly the same order of magnitude as the central force the separation of the forces was not justified, as this led to great complications in the equations. The success of direct integration of the second order differential equations for J VIII was so great that Cowell and Crommelin proceeded at once to apply the same method to the motion of Halley's Comet through two revolutions 1759–1835–1910. The results were more easily obtained and more accurate than by the classical methods.

The planets of the solar system for which the existing theories are least perfect are the outer ones and on account of their slower motion it is easier to calculate their motion step by step over a period of many years than it is for faster moving bodies. The rectangular coordinates of the five outer planets, Jupiter to Pluto, have been calculated simultaneously under a cooperative scheme directed by Eckert, Brouwer and Clemence. I am not sure of the way the credit is to be divided amongst these three. In the introduction we read that the work was planned in detail by the authors jointly and executed by them or under their immediate supervision. The comparison with observations and the determination of the constants of integration was made at the U.S. Naval Observatory for Jupiter, Saturn and Pluto and at Yale Observatory for Uranus and Neptune. This involved much labour in comparing the calculated positions with the older theories and with actual observations—the latter of course could

not be done in bulk by a machine. Theoretically the work was much more complicated than previous applications of numerical integration to problems in celestial mechanics, for previously there have been only three second order differential equations involving three unknowns. In this work there were fifteen second order differential equations each involving all fifteen unknowns in the calculation of the forces. The final result of the calculations gave the positions of the five planets at intervals of forty days for more than four hundred years, 1653–2060. Mr Sadler, in a review of this work, begins with the words:

"The publication of the coordinates of the five outer planets obtained by direct integration of the equations of motion signals the beginning of a new approach to the problems of celestial mechanics. In the inspiring scope of its conception, in the magnificence of its execution, in the speed of its completion and in the excellence of the presentation this work is indeed a worthy instrument for such a purpose; it sets a standard that will be difficult for others to attain."

In the introduction to his great work on Jupiter and Saturn G. W. Hill wrote: "The plan therefore was to form theories of Jupiter and Saturn which would be practically serviceable for a space of three hundred years on each side of a central epoch taken near the centre of gravity of all the times of observation". These theories, for which competent astronomers have expressed the greatest admiration, were introduced into the *Nautical Almanac* in 1901 and will be dropped in favour of the new theories in 1960.

In spite of the fact that the tables of Hill and Newcomb are to be superseded I would not like to give anyone the impression that the theories were not very well constructed. Slight adjustments of the orbital elements to suit the observations which have been made in the period of more than fifty years since the tables were made bring about a very close agreement with the new calculations and with the observations. There appear to be no significant errors in the theories except perhaps a fluctuation with an amplitude of not more than $2''$ in the motion of Saturn. But still we cannot be quite sure that no significant term has been omitted from the theory and tables. The simplicity of the theory behind the new calculations assures us that we can have complete confidence in the results. The calculations have been made so as to give us an extra decimal place in the positions, i.e. $0^s{\cdot}001$ in right ascension and $0''{\cdot}01$ in declination. They set a new standard for observers to aim at.

In astronomical calculations there are a number of fundamental constants for which definite values have to be adopted, such constants as the solar parallax, the mass of the Moon, the constants of precession, nutation and aberration. Values of these were adopted under the guidance of Newcomb about the end of last century. Since then various slight but inconsistent alterations have been made. When de Sitter died he had in hand the compilation of a new and consistent set of values. This work was completed by Brouwer, who has played an important role in conferences arranged to adopt the best set of values. He has also discussed other fundamental constants such as the masses of the planets.

It is not possible in the time at my disposal to refer to much important work which Professor Brouwer has done in celestial mechanics. He has been dealing with problems embracing all the bodies of the solar system as a connected whole involving new theoretical developments. As President of Commission 20 of the International Astronomical Union he has played a leading role in the organization of calculations connected with the motion of the great host of minor planets.

He has himself made calculations for several selected minor planets. He has also found time to treat special problems such as the secular changes in the orbit of Encke's comet. Another subject is the motion of a particle under the attraction of a spheroid—a theory which may find application in the motion of the fifth satellite of Jupiter. This led to a survey of the dynamics of close binary systems when the components are considered to be of spheroidal form.

These references must suffice to indicate the extensive and complex investigations in which Professor Brouwer has been engaged. He has founded a school of celestial mechanics at Yale which is revising the planetary motions—a task only undertaken now at rather long intervals of half a century or more. I should remind you that he is the successor at Yale not only of Brown but of another of our Gold Medallists, Schlesinger. As head of an active observatory with a station in the southern hemisphere he has directed the production of several star catalogues and other compilations. We look forward to hear him explain some of his work when he comes to deliver the George Darwin Lecture on " The Motions of the Outer Planets ". In the meantime we express our admiration for what he has already accomplished and wish him success in the extensive programmes on which he is at present engaged.

THE PRESIDENT'S ADDRESS

ON THE AWARD OF THE EDDINGTON MEDAL TO PROFESSOR H. C. VAN DE HULST

Dr John Jackson

The second award of the Eddington Medal has been made to Professor H. C. van de Hulst for his prediction of the 21 cm line radiation of neutral hydrogen and for his share in its detection and observation and in the theoretical interpretation of the observations.

It is not often that astronomers see such a rapid development in any branch of their subject as has taken place through the use of the new techniques for detecting and amplifying radiations of radio wave-lengths. Rather more than twenty years ago radiation of a metre wave-length was detected as coming from the Milky Way. Ten years later radiation from the Sun was detected and this was followed by the application of radar methods to the accurate observation of meteors.

The prediction of the existence of radiation of 21 cm wave-length was made by van de Hulst as long ago as 1944, when he suggested that it might be emitted in observable strength by interstellar clouds. The line arises from a transition between the hyperfine structure levels of the ground state of atomic hydrogen. For such a transition the release of energy is only of the order of a millionth of that in the transitions producing light of visual wave-length. Moreover it is estimated that this minute amount of energy is released from an atom only once in eleven million years, and with atoms something like 1 cm apart in space it is clear that great distances will be required to give any measurable radiation. The great distances with which astronomers have to cope are usually considered as a great impediment to progress: in this case the great distances have come to our help and the radiation predicted by van de Hulst in 1944 was successfully observed independently in three different continents in 1951.

The fact that the line was detected independently in U.S.A., Holland and Australia within a few months is proof that astronomers attached great importance to it. A year ago in my address on the award of the Gold Medal to Baade I had to refer to the use he made of red-sensitive plates in extending observations to regions opaque to ordinary photographic light. But even infra-red light cannot penetrate interstellar dust (not to mention atmospheric dirt) in any way comparable to radiation of 21 cm wave-length. Again the 21 cm line is well defined, so that observation of it can be used for the determination of radial velocities. Those of you who have studied papers in the *Monthly Notices* on Line Profiles during the past thirty years will know how difficult it is to interpret the photographs, as the profiles are greatly affected by the spectroscope and the behaviour of the photographic emulsion. Such difficulties hardly arise at radio wave-lengths where line profiles can be accurately determined free from distortion.

These properties of the radiation were well known to certain astronomers interested in investigating interstellar matter and in particular Professor Oort of Leiden. A team consisting of Oort, with Dr C. A. Muller as observer, and van de Hulst embarked at once on a programme to observe the profile of the 21 cm line at regular intervals along the galactic equator. The observations were made with a radio telescope utilizing a paraboloid of $7\frac{1}{2}$ metre aperture which had been used by the Germans as a radar mirror on the Dutch coast and abandoned towards the end of the war. From observations made with this telescope van de Hulst was able in his Halley Lecture in 1953 to give preliminary results. These have been extended and to a certain extent rounded off in a paper by Oort, van de Hulst and Muller published last year in the *Bulletin of the Astronomical Institutes of the Netherlands*. It must not be assumed that the observing was a light matter. For each profile determination two hours were required at the telescope and the number of such determinations amounted to many hundreds.

This is not the time to go into a detailed examination of the results already obtained. Each profile can be used to determine the intensity of radiation associated with different radial velocities of the hydrogen atoms situated in the galactic longitude to which the telescope is directed. Amongst the results already deduced is a distance of the galactic centre agreeing well with that determined by other methods and the existence of several spiral arms, the Sun being situated near the edge of one of them. The results link up well with those from other investigations into the distribution of interstellar gas, but as the latter have hitherto been based on radiation of visual wave-lengths they cannot be pursued into regions accessible to radiation of radio wave-lengths.

At present the Leiden astronomers are confining their work to the galaxy, but other astronomers have found that the 21 cm radiation can be detected in extra-galactic objects such as the Magellanic Clouds.

Although the medal is awarded for investigations concerning the 21 cm line it might be mentioned that van de Hulst has done important theoretical work in other fields involving the interaction of light and particles in the solar corona and in interstellar space.

Professor van de Hulst hopes to be present at the conversazione of the Society to be held in August when the Medal will be presented to him. In the meantime I express in your name our admiration for his work which has provided us with a powerful method for investigating the distribution and motion of gas in our own and other galaxies.

AN ADDRESS BY THE PRESIDENT

THE NEED FOR OBSERVATIONS IN THE OLDER BRANCHES OF ASTRONOMY, ESPECIALLY DOUBLE STARS

Dr John Jackson

It is now the custom for the President to address you on a subject of his own choice and as one who has spent most of his active life as a professional astronomer I would like to speak to you today about those branches of astronomy with which I have been associated during the past forty years—double stars, parallax determinations and positional astronomy.

Anyone who compares the *Monthly Notices* of today with those of forty years ago will find a great change. Now very many of the papers are of a theoretical nature based on the fundamental laws of physics applied to a universe the contents of which are adopted in a very general way from observational data. Amongst the papers which deal with actual observations a majority deal with spectroscopic observations of the Sun and stars. There is also an increasing number of papers on radio-astronomy. Changes in the work done in our observatories were bound to take place when new methods of exploring the universe became available and we welcome the new techniques. These changes have taken place in all countries where astronomical observations are made. Unless staffs have been considerably increased it has been inevitable that work has been diverted from directions in which it used to be prosecuted vigorously. I wish today to examine the position with regard to some of the older branches of activity lest we lose by neglect much of the value of the great heritage which has been handed down to us as the fruit of the labours of our predecessors.

Double Stars

I choose first of all the subject of Double Stars. It is the subject to which I devoted a good deal of time at Greenwich after the First World War. My task was to collect and discuss the observations which had been made in the preceding thirty years. The observing programme consisted principally of the Struve stars and was a good programme for that time. But since it was drawn up very many new double stars have been catalogued and it is necessary to review the position in view of these and of the steadily decreasing number of observers.

The number of pairs which have been listed at one time or another must be of the order of 40 000. Those which were found in systematic surveys with limits of magnitude and distance such as those at Dorpat, Pulkovo, Lick and Johannesburg are all important for statistical purposes. A considerable number of faint wide pairs which have been catalogued should be dropped. In fact Sir John Herschel, who was himself responsible for cataloguing many such pairs, was of this opinion when he wrote " But if small double stars are to be watched it is first necessary that they should become known; nor need we fear that the list will become overwhelming. It will be curtailed at one end by the rejection of uninteresting and uninstructive objects, at least as fast as it is increased on the other by new candidates ". The result has falsified

Sir John Herschel's prediction. The lists have indeed been increased by large numbers of new candidates many of them interesting and important, while the many unimportant pairs have *not* been rejected. Indeed Burnham's General Catalogue published in 1905 contained every pair published as a double star for that part of the sky covered by the catalogue, even those which had been rejected by the discoverers when they revised their lists. When Aitken compiled his General Catalogue containing observations up to 1927 he was firm enough to reject many pairs included in Burnham's Catalogue.

We now know enough about the average masses and average distances of ordinary stars to be able to estimate what stars may be expected to be worth observation at intervals of twenty years, and distinguish them from the many which cannot be expected to show orbital motion of more than a degree or two in the course of a century. Consider for example a star of absolute magnitude 5·0 and apparent magnitude 10·0. Its parallax is 0″·01. If it has a companion distant 5″ the actual separation is five hundred astronomical units. With a total mass equal to that of the Sun the period will exceed 11 000 years, so that the orbital motion in a century will be only a little over 3° : to double this the mass would have to be four times as large. Even with a separation of only 1″ the period would still be a thousand years so that observations at intervals of twenty years would suffice.

With these considerations in mind let us consider the W. Struve (Σ) stars. These stars were all picked up in the years 1824–1827 from amongst the 120 000 brightest stars north of declination −15° with a 9½-inch refractor, the stars being examined at rates up to four hundred an hour or one every nine seconds. The original list contained more than three thousand double stars but after various adjustments including the rejection by the discoverer himself of several hundred there remained 2659 brighter than magnitude 9 or thereabouts and with a separation less than 32″. Most of these stars had been observed at several epochs before they were put on the Greenwich observing list and when I discussed them in 1922 I found that only 649 (24 per cent) showed relative motion. For 449 (17 per cent) the motion was beyond question orbital, for 161 (6 per cent) it was clearly the result of difference in proper motion so that the pair of stars formed only an optical double. For the remaining 39 pairs (1 per cent) showing relative motion it was difficult to decide whether they formed binary or merely optical systems. Generally speaking stars as bright as the Σ stars may be expected to have proper motions of the order of 2″ a century while binaries with periods of more than a hundred years will generally have orbital motion much smaller than this unless they are within 20 parsecs. For the 39 pairs which show rather large relative motion it is likely that the majority are merely optical systems, but some may be true binaries with a rather large parallax which could be confirmed by trigonometrical observations. No less than 2010 (75 per cent) of the Σ stars showed no certain relative motion of the components and the great majority of these must be real binaries with periods of many thousand years. This can be deduced from the facts that chance distribution could only produce a small fraction of so many close pairs and that optical close pairs could be expected to show relative proper motion in the interval of say eighty years. In fact a large proportion of all the optical pairs amongst Σ stars must be included in the two hundred pairs showing relative motion for which I classified 161 as optical. From this simple

analysis it is easy to conclude that the 2010 stars which had shown no relative motion by 1920 although true binaries hardly need any further observation till the end of this century. Moreover the 161 optical systems may also be ignored by double star observers. They are all wide enough to be observed photographically and in fact will nearly all be taken care of in the photographic observations of the A.G. zones. But surely the 449 showing orbital motion and the thirty-nine for which the nature of the motion was uncertain should be observed at intervals of say ten or twenty years till an orbit can be computed or the pair prove optical. It should be easily possible for a single observer with a telescope of 12 inches aperture to observe them all in a year or two. It would be interesting to know how they have been observed since 1920. The war has certainly reduced the number of observations made, and it has also delayed or prevented the publication of observations, but a record is being kept at Lick Observatory and it should be fairly easy to check up as I published the Σ numbers of all the stars concerned.

Now consider the OΣ stars. These were discovered with the 15-inch refractor at Pulkovo mostly in 1841 or 1842. They were discovered in an examination of about 17 000 stars down to magnitude 7 or 8 and had been missed in the earlier examination of 120 000 stars. They are on the whole considerably more difficult to see and observe accurately, as the components are closer and less equal in brightness. After various corrections had been made to the lists there remained 425 pairs to be considered. Although many of these stars are difficult they were, like the Σ stars, well observed last century by various observers, and a discussion of them is made easier by the work of Hussey who re-observed them all with the 12 and 36 inch refractors at Lick Observatory more than fifty years after the first observation of them. When I discussed these stars in 1923 I found that 135 (32 per cent) showed orbital motion, 15 (4 per cent) were optical systems, 5 (1 per cent) showed motion of uncertain nature and that 270 (64 per cent) showed no motion. Although the OΣ stars had been observed over a shorter interval of time and accurate observation was more difficult, there was a greater percentage of stars of importance for the future. This was attributable to the fact that the stars were on the whole brighter and the components closer. Here again it would be interesting to know how the 140 (33 per cent) important pairs have been observed in the last thirty years.

Before going on to discuss later lists of double stars it is worth considering for a few minutes the great importance of the really close pairs. In W. Struve's long list there were only 91 with a separation under 1″. Two have been rejected. Of the remaining 89 I found that before 1920 no less than 70 (79 per cent) showed orbital motion. That left 19 for many of which observations were few and uncertain. The spectral type of a large proportion of these indicated that they might be giants and the parallax would for nearly all be less than 0″·005. These stars should soon show orbital motion as it is difficult to attribute to them both great luminosity and small mass.

I now turn to discuss later lists of double stars found in the great survey down to magnitude 9·0 or 9·1 (B.D.) carried out by Aitken and Hussey at the Lick Observatory. The following table, taken from Aitken's work *The Binary Stars* shows the number of really close pairs in several catalogues.

The most interesting feature of this table is of course the steady increase in the percentage of really close doubles with date. There are two principal

reasons for this. The first is that the wider pairs being easy to discover were recorded by the earliest observers, so that relatively few were left to the later observers who in any case confined themselves to closer pairs, generally with separation less than 5″ or 10″ except for really bright stars. The second reason is that later observers had better telescopes often erected at sites selected because of the excellence of the observing conditions.

	Number of stars	No. 0″–1″	No. 1″–2″	Percentage 0″–2″
W. Herschel (1779–1802)	812	12	24	4·5
W. Struve (1824–1827)	2640	91	314	15·0
Otto Struve (1841–1842)	547	154	63	40·0
Burnham (1870–1892)	1260	385	305	55·0
Hussey (1899–1905)	1327	674	310	74·2
Aitken (1899–1915)	3105	1595	710	74·3

We know that after a period of about ninety years 79 per cent of the Σ stars with separation under 1″ had shown orbital motion and that after seventy-five years 65 per cent of the OΣ stars had shown motion. As much as 60 per cent of the Aitken and Hussey stars with a separation under 1″ have a separation under half this amount. I have no doubt that by this time accurate observations of the Aitken and Hussey as also the Burnham stars would show that 50 per cent of those with a separation under 1″ and 25 per cent of those with a separation between 1″ and 2″ would show orbital motion, say 1650 in all as compared with a total of about 600 for all the Σ and OΣ stars.

Aitken made observations at a second epoch, of all the double stars he had himself discovered and when he found relative motion he made further observations. By 1933 he was able to determine dynamical parallaxes for 323 of them, which number he increased to 411 (13 per cent) by 1937. Van Biesbroeck reobserved all the Hussey stars in the period 1917–1925 and classified them in much the same way as I did the Struve stars. Even after an interval of only twenty years or so he found that 253 (19 per cent) showed orbital motion. We are greatly indebted to Van Biesbroeck who when long past the normal age for retirement and in the midst of other work has continued to observe the Aitken, Hussey, Burnham and other close double stars with the 40-inch Yerkes refractor and the 82-inch McDonald reflector. In the preface to a wonderful volume of measures of the most difficult double stars which he made in the course of fifteen years and which has recently been published he wrote :

" It will be seen that the majority of the stars are close orbital pairs which are followed by only very few observers at this time. In spite of all my efforts many of these stars are insufficiently observed so that neither periods of revolution and therefore masses nor dynamical parallaxes can be deduced although often the star may have described its orbit more than once since discovery."

Van Biesbroeck's volume contains roughly 10 000 measures of two thousand double stars, some of the most important having been frequently observed. It is however a rather sad commentary on the state of double star observations that known double stars may complete a revolution without being well enough observed for the elements to be determined.

In drawing the attention of possible observers to these important stars it must be pointed out that observing is not easy and that the very close pairs can only be observed with a fairly large telescope under first class observing conditions.

Still there are many pairs which could be observed with a telescope of 12 inches aperture. On account of the difficulty of observation and the scarcity of observers the double stars discovered in the Lick and other surveys have fared very badly compared with the Σ and OΣ stars. The latter stars were measured not only by the original discoverers but by a goodly number of later observers. Dembowski observed them systematically and accumulated about 21 000 sets of measures by 1878 when he was awarded our Gold Medal. The three great American observers Burnham, Aitken and Hussey besides discovering some thousands of new double stars made extensive series of observations of the Struve stars. Greenwich provided its quota of measures of these stars and the fact that the mounting of the 28-inch refractor made it impossible to observe stars within 20° of the Pole, or stars in the zenith, is reflected in the scarcity of observations of stars in these regions. There were other observers, amateur as well as professional, who devoted much time to this work although the absence of programmes planned to meet the most urgent needs resulted in some stars being over-observed while others were neglected. But compared with the Burnham, Aitken and Hussey double stars we may say that the Struve stars were well observed.

I therefore conclude that one of the most urgent needs of observational astronomy at the present time is the systematic re-observation of important double stars for which we have already detected the beginnings of orbital motion. The position may not be quite so bad as it appears as there may be a number of measures of double stars not yet published and the absence of a general catalogue giving observations later than 1927 makes it difficult to estimate the true position. Nevertheless the reports of the International Astronomical Union do indicate a steadily decreasing number of measures.*

So far I have dealt only with stars in the northern sky down to about magnitude 9·0 on the B.D. scale, corresponding to about 10 on a photometric scale. Similar work has been done in the southern hemisphere, principally at Johannesburg and Bloemfontein in this century and mostly after 1925. To make full use of this work it will be necessary for the stars to be re-observed at future epochs and it may be as difficult to arrange for the observations as it is proving in the north.

But I would like now to say a little about the observations of fainter stars. As a result of the zeal of a number of observers such as Jonckheere in France (and at Greenwich 1914–1919), Espin and Milburn in England and Rossiter at Bloemfontein several thousand fainter stars with a separation under 5″ have been discovered and catalogued since 1900. It is difficult to estimate what proportion of these stars will show orbital motion in the next fifty or hundred years. On the average of course they will be more distant than the brighter stars so that orbital motion will appear to be slower than for brighter pairs with the same apparent separation. But we do know that faintness is not an infallible guide to distance and a certain proportion of these stars will be relatively near and so may show orbital motion. With the number of observers limited it is clear that it will be impossible to get numerous observations of these stars without interfering with observations of the brighter ones. Still a certain fraction should be

* Since this address was prepared I have seen with much pleasure the measures of many extremely close double stars made by Dr. Muller of Strasbourg during a four months' visit to Lick Observatory. He was able by means of his own measures and those of Van Biesbroeck to calculate first orbits for no less than thirteen double stars distributed amongst the discoverers as follows: Aitken 5, Burnham 3, Hussey 2, Kuiper 2, and Otto Struve 1.

observed so that we may get some information about them. Jonckheere indeed has found motion in a considerable number of these stars in the course of thirty or forty years and a continuation of observations of them is desirable. But I am strongly of the opinion that it is not desirable at present to continue the search for double stars to fainter and fainter magnitudes indiscriminately, at the cost of observations of neglected pairs already known. If statistical information is required regarding the number of faint stars which are double we should confine our attention to stars in selected areas. Aitken has tabulated the percentage of double stars in different ranges of apparent magnitude and found that it fell off from 7·9 for stars of magnitude 6·6–7·0 to 4·1 for magnitudes 8·6–9·0. For the brightest stars the percentage was 11·1. Aitken did not believe that this could be attributed to incompleteness in the observational data. It is difficult to accept the idea that it is due to change in the nature of double stars over such a short range of apparent magnitude and much shorter range of absolute magnitude. In an attempt to settle this question let us consider the number of known double stars for different ranges of separation and brightness. The following table is based on data given by Aitken.

Distribution of double stars in angular separation and magnitude (B.D.)

Magnitude	Separation			
	0″·00 to 0″·50	0″·51 to 1″·00	1″·01 to 2″·00	2″·01 to 4″·00
≤ 6·5	75	63	83	103
6·6–7·0	82	52	59	82
7·1–7·5	103	67	99	112
7·6–8·0	178	132	164	192
8·1–8·5	310	223	285	301
8·6–9·0	508	413	532	534
Total ≤ 9·0	1256	950	1222	1324

Percentages of doubles in complete range to 4″·00

≤ 6·5	23·1	19·4	25·6	31·8
6·6–7·0	29·8	18·9	21·5	29·8
7·1–7·5	27·0	17·6	26·0	29·4
7·6–8·0	26·7	19·8	24·6	28·8
8·1–8·5	27·7	19·9	25·5	26·9
8·6–9·0	25·6	20·8	26·8	26·9
Total ≤ 9·0	26·4	20·0	25·7	27·9

The most striking feature about the part of this table giving the percentages for each distance range is the independence of the result on magnitude. Aitken states that there are 379 stars with separation 0″·25 or less and if these are subtracted from the total for the first column we get the following percentages for each of the four distance groups, each double the preceding one:

20·1, 21·7, 27·9, 30·3.

This shows a steady progression but I am not inclined to consider it as very significant. A tendency to progression in this way would result from the difficulty of detecting the really close pairs. I interpret the result to mean that the number of pairs with a given separation decreases nearly inversely as the separation increases—in fact roughly as the distribution of planets in the solar system.

But there is a further difficulty. Let us consider the percentage of double stars to all stars over different ranges of magnitude and separation.

Magnitude	Separation			
	0″·00 to 0″·50	0″·51 to 1″·00	1″·01 to 2″·00	2″·01 to 4″·00
⩽ 6·5	1·82	1·53	2·01	2·50
6·6–7·0	2·11	1·34	1·52	2·11
7·1–7·5	1·70	1·11	1·64	1·85
7·6–8·0	1·59	1·18	1·46	1·71
8·1–8·5	1·35	0·97	1·25	1·31
8·6–9·0	0·96	0·78	1·01	1·01

This table shows the falling-off of percentage with decreasing brightness already mentioned as well as the variation with separation. If change in apparent magnitude were merely due to change in distance we should expect the percentage for ranges 8·1–8·5 and 8·6–9·0 to be nearly the same as those for 6·6–7·0 and 7·1–7·5 with double the separation, as the change in brightness corresponds to a factor two in the distance. This is by no means the case.

It has been known before that the number of double stars falls off with increasing separation but so far as I know it has not been previously suggested that it falls off inversely as the distance. I estimate the range covered by the table to be from 0″·25 to 4″·00 in separation and say from 0″·01 to 0″·004 parallax, that is from linear distances 25 to 1000 astronomical units. It is clear that the law cannot be extended indefinitely in either direction.

The counts of double stars indicate that something like 1 per cent of all stars are binaries within the range of separation r to $2r$. There are ample stars for the law to hold right down to spectroscopic binaries with a separation of a tenth of an astronomical unit or less with periods of the order of a day. A similar extension with increasing separation would bring us to separations of the order of a parsec when the gravitational attraction would become almost insignificant.

Although my counsel is to suspend further search for double stars along conventional lines there are special stars worthy of exceptional attention. We are always anxious to bridge the gap between visual and spectroscopic binaries and the only hope of doing so is by finding double stars amongst the nearest stars. The observations of Kuiper who has examined stars of large proper motion and large parallax are of great importance in this connection. Finsen's search with an interferometer amongst the brightest stars of the southern hemisphere has also yielded a fair number of doubles which may prove to be short-period binaries.

Double stars are of importance to astronomy in several ways. Statistically we want to know the proportion of stars which are double and the separation of the components : to make full use of the catalogues we require more accurate magnitudes and spectral types. We wish to get the orbits of as many binaries as possible. Those with parallaxes give us the means of determining the masses of systems. We must be careful to make allowance for any selection which may easily arise in the data. For example the shorter the period the more likely are we to be able to determine the orbit, and as increase of mass decreases the period we automatically get data for the more massive systems first. Again it used to be thought that long periods are associated with large eccentricity. But as Finsen pointed out the observed result can be explained as the result of selection. If a binary has a period of several centuries and the orbit is circular, the motion will be too slow for us to have accumulated enough observations for orbit calculation. For a very eccentric orbit the motion near periastron is much faster, in which case data for orbit calculation accumulate in a shorter time. The fact that long-period binaries with large eccentricity have all been observed near periastron shows that this selection has been at work. Long-period binaries with circular orbits and long-period binaries with eccentric orbits but with the components near apastron have not yet shown sufficient motion to allow of the calculation of an orbit.

Stellar Parallax

The position with regard to parallax determinations presents almost as great a contrast as is possible to the measurement of double stars. About forty years ago, the great international scheme devised by Schlesinger for the mass determination of parallaxes was taken up at a dozen observatories which possessed powerful long-focus telescopes. As a result of this work Yale Observatory was able to publish two years ago a General Catalogue of Trigonometric Stellar Parallaxes. This catalogue based on data available by May 1950 gives the parallaxes of 5822 stars from about 10 000 determinations. Compared with the parallax observations made in the last forty years all the work previously done might be rejected as negligible. In his book *The Stars* published in 1904, Newcomb gave a list of all the parallaxes known to him. There were in all seventy-two stars for fifteen of which it was noted that the results were subject to more doubt than usual while one was stated to be entirely unreliable. During the recent campaign several observatories gave longer lists every year and each determination had ten times the weight of the combined observations of the nineteenth century. The scheme drawn up by Schlesinger called for the observation of all stars as bright as magnitude 5·5 except stars of type earlier than A and late-type giants for which only a very small parallax might be expected. All these observations have been completed from pole to pole and many more stars for which large parallaxes could be anticipated have also been observed. These other stars, selected mostly on account of large proper motion and some of which are fainter than magnitude 12, include many of the intrinsically faint stars nearer than 20 parsecs. Several of the telescopes which have completed their programmes are now used for the intensive observation of the nearest stars in the search for companions too close or too faint to be discovered except by the periodic displacement of the centre of light. A number of stars have been proved to have companions moving in orbits with periods of a year or

two. Periods of the order of a few days can best be found or indeed only found by spectroscopic observations for radial velocity. Parallax observations for the next few years may be confined to filling in the gaps made by the omission of stars of early and late types, to the observation of certain specific stars, e.g. double stars or Vyssotsky's stars with dwarf characteristics and to unravelling some of the large discordances. At the present time it is unlikely that any star within 10 parsecs will be passed over unobserved unless it is too faint for the refracting telescopes. The most valuable parallax determinations at the present time would be of very faint stars with large proper motion. For these a large reflector is necessary.

As it is there is a tendency to employ the parallax telescopes on other work such as photometry, spectroscopy and the determination of mass ratios and proper motions. The success of Schlesinger's programme has been so great that most really large parallaxes, at least those in the northern hemisphere have been measured at several observatories. The three largest parallaxes in the north are $+0''{\cdot}545 \pm 0''{\cdot}003$, $+0''{\cdot}402 \pm 0''{\cdot}010$, $+0''{\cdot}398 \pm 0''{\cdot}005$ measured at nine, two and four observatories respectively. The first and third are classified as unresolved astrometric binaries, the other is of magnitude 13·5, all three have M-type spectra.

Meridian Astronomy

The observation of stars with meridian instruments for the determination of their positions (and the time) was formerly the staple work of all permanent observatories. We have had catalogues from Cambridge, Oxford, Glasgow, Edinburgh and Armagh and even from a private observatory at Blackheath where Stephen Groombridge observed many circumpolar stars nearly a hundred and fifty years ago.* Now the Royal Greenwich Observatory is the only observatory in this country where such observations are carried out. In some other countries there have been changes involving the elimination of meridian observations, but in Germany this work is maintained at a high level, while in the U.S.S.R. the process of expansion begun before the war has been continued since. These changes have taken place partly as a result of our changing outlook on the purpose and needs of meridian astronomy. Observatories established merely for time determination can no longer be justified in carrying on this work unless they are reaching an accuracy comparable with that of the great national observatories. Also we are now able to determine photographically and much more economically the positions of great numbers of stars formerly observed visually with meridian instruments. With plates $5° \times 5°$ one star per square degree, i.e. 40 000 in all, or less, can be used in reducing the plates. If meridian observations are made they should be made with the greatest possible precautions against systematic and accidental errors. An observing programme should not be entered upon lightly. It will involve a lot of incidental work in checking up the instrument and unless the observations are carried on regularly for a number of years they will not add much to our present knowledge.

Some of you who have taken up the study of astronomy in the last twenty or thirty years may ask what is the use of all this meridian astronomy. You may say we understand the reason for observing double stars and for determining

* Mention should also be made of Carrington's observations of more than three thousand stars within 9° of the north pole (1854–56).

stellar parallaxes but why go in for the determination of the positions of a million stars. Granted you need the positions of a number of stars as reference points in the observation of the planets, for determining geographical positions on the Earth, and for the determination of time and latitude variation, but surely a few thousand would suffice to meet all the needs!

The simple truth is that while we only need accurate positions of sufficient stars for reducing photographic plates we do want the proper motions of as many stars as possible and as accurately as possible. This involves the *positions* at two or more epochs. We want the proper motions of stars of all degrees of brightness, of all spectral types, of all kinds of variability, in all galactic longitudes and latitudes. Proper motions enable us to get the average distance of groups of stars far too distant for trigonometric determination. They thus are important in investigations concerning the content of the Milky Way system at distances greater than a hundred parsecs, besides of course showing the systematic and random motions of the stars themselves. The unfortunate thing is that the proper motions are so small, and as we cannot afford to wait centuries we must attempt to get the utmost accuracy possible in the few years at our disposal. By comparing photographs taken at intervals of twenty years or more we get proper motions relative to the background of faint stars and now we are very anxious about the background and methods of making the relative motions absolute.

In the past, absolute proper motions have been determined by comparing meridian observations made at two or more epochs. These observations are made relative to a moving equatorial system of co-ordinates and the motions of the stars are absolute only in so far as the motion of the equatorial system is correctly determined. For practical purposes we have set up fundamental catalogues giving the positions of something like a thousand stars together with their proper motions and the precessional constants. If the precession is altered so must be the proper motions. Fundamental catalogues have been steadily improved in the past hundred years and whereas up to 1900 they were based on observations beginning with Bradley 1750–1762 we now pay little attention to observations made before 1850. Indeed in the recently published Washington Catalogue N30, which however is not rated quite as a fundamental catalogue, the proper motions were derived from normal places round 1900 and 1930. The recent advances have come from improved methods of observation such as the use of screens and self-registering micrometers and a more careful investigation of the instruments for systematic errors. We still have no declination system free from criticism to the extent of 0″·1 at the equator and when an adequate method is developed it will require years of observation to get over the accidental errors. On account of the relatively short time since 1900 during which the improved methods have been used it is important to carry on the observation of the fundamental stars although further advances should be possible when we can replace the human eye by some automatic recorder. Observations are most urgently needed in the southern hemisphere where the Cape Observatory almost alone has carried on the burden of fundamental meridian work.

The fundamental system most generally adopted at present is the FK3 system of only 1535 stars including the Zusatz-Sterne. This is being supplemented by about two thousand other bright stars making a total of about 3500.

But these stars are too bright to be suitable for standardizing photographic plates and in any case they are too small in number for this purpose. To reduce plates covering an area of 5° by 5° we want at least one star to every two square degrees, or 20 000 for the whole sky. This is too large a number to be adequately observed as fundamentals and it is proposed to use a smaller number of faint stars as fundamentals to be tied on to the bright fundamentals and to be used for determining the positions of the whole 20 000 differentially, with meridian circles. There is a difference of opinion both as to the number and brightness of the faint fundamentals. The Germans favour as many as 3000 to be selected from the reference stars used in the recent photographic repetition of the A.G. zones, the selection being guided by the existence of early reliable observations of the stars. On the other hand the Soviet astronomers favour only a third as many faint fundamentals and prefer to stop at stars of magnitude 9 rather than magnitude 10 which the Germans seem able to observe with their meridian instruments but which most other observers think too faint for accurate work. Astronomers in both countries are already at work on their programmes, no less than eight observatories in the U.S.S.R. taking part.

Almost at the same time twenty years ago when the scheme for a fundamental catalogue of faint stars was being discussed, new ideas for improving our fundamental catalogues were brought forward. One proposal was to use minor planets (comparable in brightness with the faint fundamentals) to replace the Sun and interior planets for fixing the equinox and zero of declination and even to check the fundamental system for systematic errors depending on the right ascension and declination. Although I feel that it will be difficult to separate these errors from the elements of the orbits of the minor planets, these observations would certainly help in fixing the position of the equator and equinox. Much work has already been done on this plan and indeed our Gold Medallist has devoted a good deal of his energy to it.

Another plan gradually came forward after it had been realized that most of the faint nebulae were extra-galactic and could be considered as almost fixed relative to anything in our galaxy. If we merely want absolute proper motions and are not specially interested in positions this plan is ideal. It has been taken up enthusiastically in Russia where many photographs have been taken with telescopes of astrographic size and fields 2° by 2°. A selection has been made of 157 fields north of declination −5° containing 468 measurable galaxies of magnitude 14. The plates already taken may be considered as satisfactory for the first epoch and could be used in the future for determining the absolute proper motions of the fainter stars on the plates. But I am not sure that preparations have been made for linking these stars with the brighter stars observed with meridian circles. The problem has however been considered and the difficulty of connecting stars of different brightness realized. It may be possible to make the link by utilizing proper motions derived from the Astrographic Catalogues or Selected Areas. But the best way is that being used at Lick Observatory which has the best telescope for this work—the large wide-angle Carnegie photographic refractor. Over a thousand plates each 6° by 6° have been taken covering the whole sky north of declination −23° with exposures of two hours and of one minute. In taking these plates a wire grating giving a difference of four magnitudes between the first-order spectral images and the central images was used. The long exposures give stars down to magnitude 19 and nebulae to 18·3. The

use of the grating and two exposure times provides a means of connecting stars over a range of more than 8 magnitudes without using over-exposed images. From a single plate it is thus possible to connect faint nebulae with stars bright enough to be observed with meridian instruments. It will be most interesting in thirty years' time to check up from these observations how near to absolute our proper motions are. The greatest weakness in the plan is the lack of observations in the southern hemisphere. Without these the normal equations for determining secular parallaxes and galactic rotation are hardly independent, so that the values of the unknowns will come out with large probable errors. A telescope in the southern hemisphere similar to that at Lick Observatory is urgently required.

There is one other aspect of meridian observations to which I may refer and in which this country is playing an important part—accurate time determinations. These have often been considered as a by-product of transit observations but of great practical importance to the community. When wireless was first used to distribute time signals it was realized that determinations made at different observatories sometimes differed by much larger amounts than had been anticipated. This led to renewed efforts to improve the results. Other urges in the same direction came from demands from radio engineers for more accurate time signals, the introduction of better time-keepers in the way of quartz clocks which showed up the irregularities in the astronomical observations and finally the hope of checking the irregularity of the rotation of the Earth revealed by the motion of the Moon and other celestial bodies. In the work of accurate time determination our own Royal Observatory takes a satisfactory position and we look forward with interest to see the Photographic Zenith Tube in action. The limit of attainable accuracy should be set by the atmosphere. I do not know of any satisfactory determination of the size of the errors introduced into positional work by irregular refraction. They will depend on the locality, on the zenith distance and the weather. In this connection I recall a point once raised by Schlesinger. For nearly all observatories which took part in the parallax work the probable error of a good plate was about $''\cdot025$ so that residuals as large as $0''\cdot1$ were not uncommon. Only a small part could be explained by errors of measurement or behaviour of the photographic plate, so that apparently the larger part must arise from atmospheric disturbance although only the relative positions of stars a fraction of a degree apart were involved. Schlesinger showed in his George Darwin Lecture that star trails on a photographic plate showed similar irregularities over a degree or more. But these irregularities were of the order of $1''$ with perhaps a tenth of this amount in the relative positions. The residuals in parallax plates might therefore arise from atmospheric effects. For absolute observations such as time determinations with stars in the zenith we might easily get errors of $0^s\cdot01$ due to the atmosphere and even with the best instrument we shall require a considerable number of stars to get time determinations for which the third decimal place is really significant. But in any case we look forward to the P.Z.T. giving us important results on the rotation of the Earth and a new standard of accuracy in the relative right ascensions of zenith stars.

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RADIAL VELOCITIES OF SOUTHERN B STARS DETERMINED AT THE RADCLIFFE OBSERVATORY*

(PAPER I)

M. W. Feast, A. D. Thackeray and A. J. Wesselink

Summary

The application of the Radcliffe Cassegrain spectrograph to the determination of radial velocities together with tests of its performance are described. Flexure effects at large hour-angles and on reversal of the telescope are found to be insignificantly small. 59 plates of IAU standard stars (mostly from the list of faint standards) give a zero-point difference of IAU − Radcliffe = +0·90 ± 0·34 (s.e.) km/s. New velocities have been determined of 147 southern B stars selected according to the following criteria: (1) HD type B5 or earlier, (2) GC visual magnitude 7·5 or brighter, (3) Declination south of −35°, (4) odd minutes of R.A. (1950). For the great majority of these stars the velocities depend upon five or more plates. Spectral types and luminosities on the Morgan system have been estimated. Photoelectric colours and magnitudes of the stars are being determined at the Cape Observatory. In addition, radial velocities have been measured for 38 B stars, mostly southern, for comparison with velocities previously determined at other observatories.

Two diagrams (p. 218) illustrate the galactic rotation effects as shown by 145 stars with new velocities and by the interstellar gas (from 53 stars with well-established interstellar *K* lines). The sample of stars observed has an average distance probably somewhat less than 1 kpc. The velocities seem to be free from systematic motions associated with the Scorpio–Centaurus group.

* The full text of this paper is published in *Memoirs of the R.A.S.*, **67**, Part II, 1955.

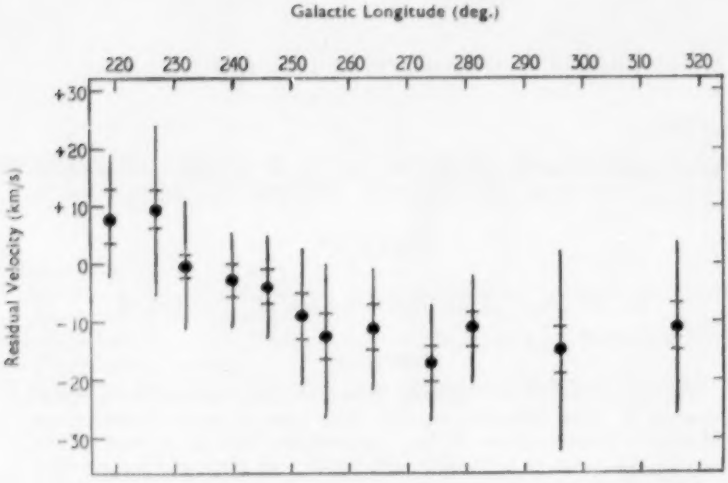

FIG. 1.—*Galactic rotation from 145 southern O–B stars (m=5·8 to 7·5). The vertical lines correspond to the velocity dispersion within each longitude group; the lines are crossed by horizontal dashes at the limits corresponding to the standard error of the mean.*

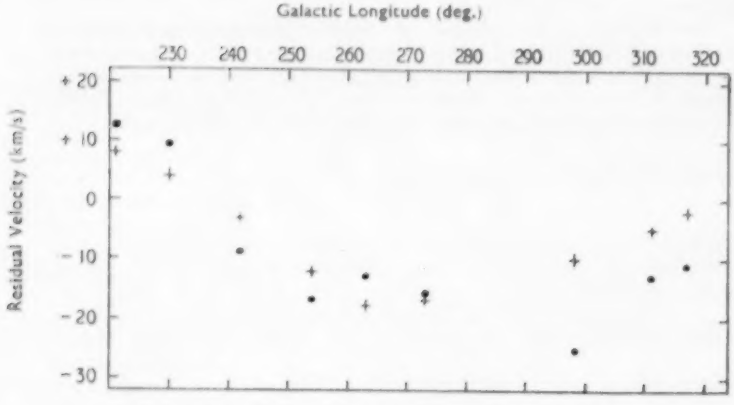

FIG. 2.—*Galactic rotation from 53 stars showing interstellar lines.*
• *Mean stellar residual velocity.*
\+ *Mean interstellar residual velocity.*

The full text of this paper is published in *Memoirs of the R.A.S.*, **67**, Part II, 1955.

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